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# **SUGARBEET RESEARCH**

**1996 REPORT**







## FOREWARD

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# **SUGARBEET RESEARCH**

## **1996 REPORT**

### **Section A**

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# ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION, 1996

DUFFUS, J.E. The Luteoviruses - aura and aureate. Proceedings International Luteovirus Conference. Cirencester. UK., pg. 9. 1997.

The yellowing and reddening of fields that took place in so many crops throughout the world had long been blamed on natural factors such as aging or nutrient deficiencies. But as difficult as the concept of virtually universal viruses causing nutrient deficiency-like symptoms has been for the agricultural community to accept, the impact of the losses was unmistakable. The viruses with special affinities to the phloem, that induce stunting of infected plants and patterns of interveinal yellowing or reddening, that show rolling and brittleness of infected leaves, are the most important artificial group of plant viruses in relation to crop damage.

The viruses inducing the yellowing diseases fall into two currently recognized virus groups--closteroviruses (transmitted by aphids, mealy bugs and whiteflies) and luteoviruses.

The viruses, described originally from a number of different crop species from throughout the world as unique and distinct plant viruses transmitted by aphids in a persistent manner, are an interrelated group of viruses termed luteoviruses.

Early serological studies showed that epidemiologically distinct viruses were many times closely related, and all seemed to be related to beet western yellows virus (BWYV). The viruses seem to form a continuum, but with clustering in regard to serology, host range and vectors.

The focus on aphids, specificity of transmission, host range, and host prevalence has been important on these yellowing diseases because these factors are the key to understanding the ecology, control, and perhaps the origins of these diseases.

Most of the definitive luteoviruses have very narrow and specific host ranges involving one, or perhaps two, plant families. BWYV infects all plant subclasses, orders, and families susceptible to the other luteoviruses. Primeval aphids were polyphagous, and primitive yellowing viruses probably infected a wide range of hosts. Transmission into plant groups with host-specific vectors probably gave rise to the monofamily viruses.

DUFFUS, J.E. Tomato infectious chlorosis virus -- transmitted by the greenhouse whitefly. Proceedings 11th Annual Tomato Disease Workshop, Windsor, Ontario, Canada, pp. 74-77. 1996.

A new virus of tomato and other crop and weed hosts was found in California. Tomato plants affected by the virus exhibited interveinal yellowing, necrosis and severe yield losses. The virus, tomato infectious chlorosis virus (TICV), is transmitted in a semi-persistent manner by the greenhouse whitefly, *Trialeurodes vaporariorum*. The host range of the virus includes 26 species in 8 plant families including tomato (*Lycopersicon esculentum*), potato (*Solanum tuberosum*), tomatillo (*Physalis ixocarpa*), artichoke (*Cynara scolymus*), lettuce (*Lactuca sativa*), petunia (*Petunia hybrida*) and zinnia (*Zinnia elegans*). Purified virus preparations contained long, filamentous particles 12 x 850-900 nm. The virus is not mechanically transmitted or transmitted by *Bemisia*. ELISA tests and dot-blot analysis demonstrated that antisera or probes against TICV reacted with purified TICV and reacted to TICV-infected tissue from tomato, potato, *N. clevelandii*, *N. benthamiana*, and *D. wrightii*, but not with healthy plants of the same species. The antisera or probes did not react with plant species infected with other whitefly-transmitted viruses,

beet pseudo yellows, lettuce infectious yellows, or cucurbit yellow stunting disorder. The virus has been found in a number of different locations in California and in Italy, and has a number of potential vehicles of movement including greenhouse grown ornamentals, tomato transplants, artichoke cuttings and potato tubers. The virus has the potential to spread to other growing regions with resident populations of the greenhouse whitefly.

DUFFUS, J.E. Whiteflies and whitefly-borne virus epidemics. Proc. XX International Congress of Entomology, p. 456. 1996.

Whitefly-transmitted viruses are a rapidly increasing threat to world agriculture. The years since the mid-1970's until the present have seen the threat of these viruses greatly intensify. The magnitude of the problem with increases in whitefly population densities and the occurrence of whitefly-borne viruses in the tropics and in wide areas of the subtropics, including areas of intensive agricultural production such as the Mediterranean region and southern United States, is largely unexplained. The intensified losses have been attributed to the widespread use of synthetic organic insecticides, resistance to pesticides, enhancement by pesticides, changing climatic conditions, intensified agricultural practices and the international transport of plant material with contaminant populations of whiteflies. Even though some of the diseases induced by these viruses have been known since the early 1900's, and the number of diseases has been estimated at over 100, only relatively few have been characterized, understood, and controlled. Intensified studies on the biological factors and mechanisms of virus distribution including host range, vector transmission, and vector biotypes, are crucial to devising strategies for their control.

DUFFUS, J.E. Whitefly transmitted viruses - Ecology, distribution and control. Proc. Bellagio Whitefly Conference "Whiteflies and viruses: Menace to World Agriculture," p. 18. 1996.

A major challenge of virologists for the first decade of the 2000's is the need for an increased emphasis on the biological and ecological parameters of the rapidly increasing disease menace induced by whiteflies. The tremendous increase in whitefly distribution and population over the last two decades has been largely unexplained. The number of "new" or previously undescribed whitefly transmitted viruses is increasing rapidly and losses are being induced at an alarming rate.

All of this is occurring in a radically changing world of agricultural research downsizing, computer technology and molecular biology. Knowledge of the biological factors and mechanisms of virus distribution, including host range, vector transmission and vector biology are critical to understanding the increasing distribution and control of these destructive diseases. A discussion of a newly emerging virus group, the whitefly-transmitted closteroviruses, will illustrate the value of intensified studies on the biological factors and mechanisms of virus distribution.

DUFFUS, J.E., P. CACIAGLI, H.-Y. LIU, G.C. WISLER, AND R. LI. Occurrence of tomato infectious chlorosis virus in Europe. Silverleaf Whitefly: 1996 Supplement to the Five Year Plan. U.S. Dept. Agr. ARS No. 1996, pg. 33. 1996.

A new virus to tomato and other crop and weed hosts was found in California in 1993. Tomato plants affected by the virus exhibited interveinal yellowing, necrosis and severe yield losses. The virus was described as tomato infectious chlorosis virus (TICV), and is transmitted in a semi-persistent manner by the greenhouse whitefly, *Trialeurodes vaporariorum*.

A tomato plant showing unusual malformation and leaf reddening, stunting, and poor fruit set was observed in a glasshouse at Albenga, Liguria, north western

Italy. The plant was shown to be infected with a closter-like virus transmitted by *T. vaporariorum*.

The Italian virus isolate was transmitted to tomato and a few other members of the Solanaceae. The virus particle size, insect transmission and lack of a serological response to beet pseudo yellows virus (BPYV) and lettuce infectious yellows virus (LIYV) was similar to the TICV from California.

ELISA tests demonstrated that antiserum against TICV reacted with tomato tissue infected with TICV from California and the Italian isolate, but not with tissue from healthy plants. Complementary DNA corresponding to the virion RNA isolated from TICV-infected tissue was cloned. Digoxigenin-labeled riboprobes reacted specifically with RNA extracted from TICV-infected plants and from plants infected with the Italian isolate in dot blot analyses. No hybridization reactions were observed with other whitefly-transmitted closteroviruses including BPYV, LIYV, lettuce chlorosis, or cucurbit yellow stunting disorder.

DUFFUS, J.E., H.-Y. LIU, G.C. WISLER, and R.H. LI. Lettuce chlorosis virus--A new whitefly transmitted closterovirus. Eur. J. Pl. Path. 102:591-596. 1996.

A previously undescribed virus disease of lettuce, sugarbeets, other crop and weed hosts was found in the southwest desert regions of USA. Affected lettuce and sugarbeet hosts exhibited interveinal yellowing, stunting, rolling, and brittleness of affected leaves. Since 1990, yellowing symptoms on desert lettuce and sugarbeet were shown to be induced by a mixture of lettuce infectious yellows virus (LIYV) and this previously undescribed virus termed lettuce chlorosis virus (LCV). LCV is a closterovirus with flexuous, filamentous particles 800-850 nm long. The virus is transmitted efficiently by both *Bemisia* biotypes. LCV differs significantly from LIYV and other previously described viruses in host range (LCV does not infect the Cucurbitaceae), insect transmission, and serology.

DUFFUS, J.E., G.C. WISLER, H.-Y. LIU, R.H. LI, G.W. SIMONE and R.C. HOCHMUTH. Whitefly transmitted tomato leaf yellowing viruses--a disease complex. Proceeding 12th Annual Tomato Disease Workshop, Columbus, Ohio (In press). 1997.

The recent discovery of a new tomato infecting closterovirus in Florida suggests that the leaf yellowing syndrome in tomato is induced by a complex of viruses. Tomato infectious chlorosis virus (TICV) was originally found in the field in southern California in 1993. The virus was transmitted by the greenhouse whitefly, *Trialeurodes vaporariorum*. The virus has been subsequently found in greenhouses in northern and central California, greenhouse- and field-grown tomatoes in North Carolina and in Italy. A new closterovirus termed Tomato chlorosis virus (ToCV) was recently identified in greenhouse-grown tomato plants in north central Florida in 1996. This syndrome in Florida was previously called "yellow leaf disorder" and was attributed to pesticide phytotoxicity, physiological or nutritional disorders. The new virus is transmitted by four whitefly species including *T. vaporariorum*, *T. abutilonea*, *Bemisia tabaci*, and *B. argentifolii*. ToCV is similar to TICV in symptomology but is distinct from TICV and other whitefly-transmitted closteroviruses based on lack of serological cross-reactivity, and lack of cross reactions in molecular hybridization studies.

DUFFUS, J.E., G.C. WISLER, H.-Y. LIU, E.G. RUPPEL, and E.D. KERR. A new aphid-transmitted yellowing virus disease of sugarbeet in Colorado and Nebraska. J. Sugar Beet Research (In press). 1997.

A disease of sugarbeet exhibiting severe foliage yellowing and necrosis has been occurring with increasing frequency in Colorado and Nebraska during

recent years. Symptoms resemble those induced by beet western yellows virus (BWYV), including yellowing of the older and middle leaves, thickening, brittleness and the development of *Alternaria* on the yellowed tissue. The virus inducing this disease has been shown to be transmitted by the green peach aphid. Preliminary host range, serological and molecular studies indicate that the new virus is not BWYV. The host range is distinct from common isolates of BWYV found in the USA and from typical isolates of beet mild yellowing virus (BMV) which is found in Europe. This new virus can be distinguished from BWYV and BMV by its ability to infect *Chenopodium capitatum* but not *Capsella bursa-pastoris*. Serological and molecular studies have indicated differential reactions from BWYV and BMV, but have not yet produced a specific probe to distinguish the virus. The disease appears similar to yellowing isolates found in California and Texas, and thus may have wide distribution. Little information is presently available regarding the ecological and epidemiological factors that allow this virus to increase over such a wide area.

HARRIS, K.F., Z. PESIC-VAN ESBROECK and J.E. DUFFUS. Anatomy of a virus vector. *Bemisia* 1995: Taxonomy, Biology, Damage, Control and Management, pp. 289-318. Intercept, Ltd., Publishers, Andover, Hants, U.K. 1996.

In this chapter on the anatomy of *Bemisia*, we have attempted to give equal weight to form and function. Also, wherever possible, form and function in *Bemisia* have been compared to form and function in similar structures and organ systems in other, more thoroughly studied and better understood, homopteran vectors of plant viruses. Finally, knowledge and ideas resulting from this comparative approach to understanding *Bemisia*'s anatomy served as a basis for our relating *Bemisia*'s morphology to the processes of noncirculative and circulative plant virus transmission.

HARRIS, K.F., Z. PESIC-VAN ESBROECK, and J.E. DUFFUS. Fate of squash leaf curl virus in squash. Silverleaf Whitefly: 1997 Supplement to the Five-Year Plan, U.S. Dept. Agr. ARS No. 1997 (In press). 1997.

*Immunogold silver staining-light microscopy (IGSS-LM)*. Thin sections (1- $\mu$ m thick) of SLCV-infected, leaf-tissue specimens were individually mounted in droplets of water on glass slides coated with 0.01% poly-L-lysine, dried at 40°C, rinsed in 0.01 M Phosphate Buffered Saline (PBS), pH 7.4, and incubated with blocking buffer [5% normal goat serum (NGS) in PBS, pH 7.4, containing 0.1% Bovine Serum Albumine (BSA) for 30 min at RT]. After five rinses in PBS, tissue sections were incubated for 2 h at RT with anti-SLCV polyclonal immunoglobulin (IgG); serially diluted 1:100, 1:500 or 1:1000 in 0.01 M PBS containing 0.1% BSA, 1% NGS and 0.02% Na<sub>2</sub>S<sub>2</sub>O<sub>4</sub> and applied at a rate of 100  $\mu$ l per section. Sections then were rinsed in PBS and distilled water, stained using a Silver Enhancer Kit (Anonymous, 1983), post-stained with methylene blue and basic fuchsin, and viewed and photographed under a Zeiss Standard 25 compound microscope.

*Immunogold-transmission electron microscopy (IG-TEM)*. Ultrathin sections (70-nm thick) were collected on formvar-coated nickel grids and floated face down for 15 min on drops of 0.02 M glycine in TRIS-Buffered Saline (TBS:20 mM TRIS-HCl, pH 7.6, plus 225 mM NaCl) to inactivate residual aldehyde groups present after aldehyde fixation. The grids then were transferred for 20 min to blocking buffer (0.1% BSA, 0.05% Tween 20 and 0.02% Na<sub>2</sub>S<sub>2</sub>O<sub>4</sub> in TBS, pH 7.6) containing 5% NGS to block the nonspecific antibody binding sites. Following incubation in anti-SLCV IgG diluted 1:100, 1:500, 1:1000 or 1:2000 in blocking buffer supplemented with 1% NGS, ON at 4°C, and rinsing in blocking buffer, the grids were transferred to goat-anti-rabbit-IgG:5nm-gold conjugate diluted to 1:50, 1:100 or 1:150 in blocking buffer for 1 h at RT, rinsed first in blocking buffer then in distilled water and stained with 4% aqueous uranyl acetate and Reynolds lead citrate. Sections were examined in a Zeiss 10C TEM at 60 V. Areas of specimen blocks for ultrathin sectioning were selected on

the basis of light microscopic examination of thin sections labeled with gold and enhanced with silver.

**Controls.** For light and electron microscopy, sections of SLCV-infected leaf tissue were subjected to nonimmune rabbit serum or blocking buffer or antiserum to lettuce infectious yellows virus (LIYV) as the substitute for the primary antibody prior to immunogold labeling and silver enhancement. Additionally, SLCV-free leaf tissue was first exposed to anti-SLCV IgG, followed by immunogold labeling and silver enhancement. Thin sections were post-stained with methylene blue and basic fuchsin and ultrathin sections with uranyl acetate and lead citrate.

Squash leaf curl virus (SLCV) was localized by immuno-gold-silver staining light microscopy (IGSS-LM) in nuclei of phloem parenchyma cells and in sieve elements of zucchini squash, *Cucurbita pepo* L. Labeling was absent from cells of the abaxial and adaxial epidermis, palisade and mesophyll parenchyma cells and tracheary elements. SLCV was localized by immunogold transmission electron microscopy (IG-TEM) in nuclei of phloem and xylem parenchyma cells and immature, maturing and mature sieve elements. Virus-induced inclusion bodies and aggregates of virions were observed in nuclei of phloem parenchyma cells and immature sieve elements. The most prominent cytopathological changes associated with SLCV infection occurred in nuclei, nucleoli, chloroplasts and mitochondria of phloem parenchyma cells. Nuclear changes included lobing, hypertrophy, degeneration, depletion of chromatin and the appearance of fibrillar bodies characteristic of geminivirus infections. Breaks in the nuclear membrane and release of virions into the cytoplasm occurred in later stages of infection until the nuclei were no longer distinct entities and virions and virus aggregates filled the cell lumen. Mature sieve elements were enucleated and contained primarily strands of P-protein, and small aggregates of SLCV virions labeled with gold. Gold-labeled SLCV also was observed in the cell walls between sieve elements and phloem parenchyma cells, between sieve elements, and between phloem and xylem parenchyma cells. The size of SLCV particles *in situ* was 14-15 nm for monomers and 14x30 nm for dimers.

HARRIS, K.F., Z. PESIC-VAN ESBROECK and J.E. DUFFUS. Morphological and cellular basis of virus transmission by whiteflies. Proc. XX International Congress of Entomology, p. 453. 1996.

*Preparation of Whiteflies for Microscopy and Immunocytochemistry.* A protocol was established for embedding whole insects in LR White at a sufficiently moderate temperature to preserve viral antigenicity. The four-step protocol includes infusing the resin with N<sub>2</sub> gas, evacuating or degassing the N<sub>2</sub>-infused resin, covering embedding molds with Aclar®, and polymerizing the resin in a N<sub>2</sub> atmosphere at 55°C.

*Whitefly Morphology and Noncirculative Virus Transmission.* The combined afferent duct, cupula, piston, efferent duct and maxillary saliva canal of *Bemisia* can be likened to a hypodermic syringe in both form and function. Saliva exiting the pump, via the efferent duct, enters the salivary canal where food from the maxillary food canal enters the antecibarium. The roof of the latter is formed by the epicibarium (inner wall or sclerite of the clypeus) and its floor by the hypocibarium (inner wall of sclerite of the hypopharynx). The postcibarium (cibarial or "sucking" pump) of the feeding apparatus functions as a reversible bellows, allowing for egestion as well as ingestion. The latter morphology suggests that noncirculative whitefly-borne viruses are "cuticula-borne": acquired by ingestion, carried at specific sites on the cuticula lining of the feeding apparatus (maxillary food canal, precibarium, cibarial valve and postcibarium) and inoculated to plants via egestion.

*Localization of Geminiviruses in Plants and Whiteflies.* The aforementioned N<sub>2</sub>-infusion embedding technique and elucidation of the internal morphology of



*Bemisia* enabled us to localize SLCV geminivirus in plants by light microscopy and silver-enhanced immunogold staining and in whiteflies by electron microscopy and immunogold labeling. Geminiviruses are circulative and presumable inoculated to plants in watery saliva excreted into the phloem.

HARRIS, K.F., Z. PESIC-VAN ESBROECK and J.E. DUFFUS. Morphological basis for whitefly transmission of viruses. Silverleaf Whitefly: 1996 Supplement to the Five Year Plan, U.S. Dept. Agr. ARS No. 1996, pg. 34. 1996.

*Bemisia*'s salivary system consists of paired primary and accessory glands in the prothorax, to either side of the thoracico-abdominal ganglion. Ducts from each pair fuse to form lateral ducts that travel anteroventrally to the midline where their duct cells fuse to form a dual-channeled medial duct that traverses the hypopharynx to join the short, single-channeled afferent duct. The latter empties posteromedially into the rim of the salivary pump's cupula. Saliva exiting the pump, via an efferent duct, enters the salivary canal of the maxillae where food from the maxillary food canal enters the precibarium. The salivary pump can be likened to a hypodermic syringe in both form and function. The pump's cupula is analogous to the wide body of the hypodermic syringe; its piston is analogous to the hypodermic's plunger, and the efferent duct and contiguous maxillary salivary canal are analogous to the narrow stem of the hypodermic syringe and its attached needle, respectively. Negative or positive pressures are created by retracting or lowering the piston, respectively. Retracting the piston by contracting the piston retractor muscles creates a vacuum that sucks saliva from the open (cupula muscles relaxed) afferent duct into the cupula. Subsequent contraction of the cupula muscles (afferent duct closed) and simultaneous relaxation of the piston muscles creates positive pressure to eject saliva from the cupula through the efferent duct into the salivary canal of the maxillae. Circulative geminiviruses apparently are inoculated to plants when whiteflies excrete virus-laden watery saliva into the phloem during "declogging" activity aimed at clearing the lumina of the feeding apparatus.

The basal part of the feeding apparatus is comprised of six exoskeletal lobes from the venter of the head capsule: clypeolabrum anteriorly, paired lora anterolaterally, paired maxillary plates posterolaterally, and hypopharynx posteriorly. Another lobe, the labium, emerges from the median of the cervical venter. The cibarium, formed by the apposition of the epicibarium and hypocibarium, is divided by a cibarial valve into antecibarium and postcibarium. The latter functions as the cibarial or "sucking" pump. The cibarium's wholly noncellular, cuticular walls and the origin of its valve and pump retractor muscles from the anteclypeus and postclypeus, respectively, attest its evolutionary linkage to the preoral cibarium of the more primitive orthopteroid feeding apparatus. The true mouth or opening between the cibarium and the intima-line, cellular pharynx coincides with the frontoclypeal suture and the distal-most descent of the frontal ganglion.

Similarities among the morphologies of whitefly, aphid and leafhopper feeding apparatuses further confirm the ingestion-egestion hypothesis: homopteran vectors acquire noncirculative viruses by ingestion, carry them externally on the stylets or "internally" on the cuticula-lined lumina (hence, "cuticula-borne") of the feeding apparatus, and inoculate them to plants by egestion. However, others have analyzed very similar morphological findings and concluded that homopteran vectors cannot egest and that they inoculate noncirculative viruses by "extravasation." But extravasation, a highly specialized term in medical pathology, refers to leakage of fluids, particularly blood, from vessels into surrounding intercellular spaces. It also misleadingly links noncirculative virus transmission to an unpredictable, abnormal, passive, vector activity. We propose the exact opposite: noncirculative transmission is linked to the predictable, normal, active, functional, vector activities of ingestion and egestion, and the homopteran feeding apparatus is equally equipped for both. Obviously, aphids, leafhoppers and, by morphological similarity, whiteflies too can and do

actively ingest and egest. And the fact that they can do so uninterruptedly indicates that they can create and sustain either negative or positive pressure in the pump chamber for prolonged periods during which the chamber fills (ingestion) or empties (either egestion or "swallowing"), respectively. The idea of virus inoculation by "extravasation" resulted from the mistaken notion that the cibarial pump can only be opened or closed at its anterior end. However, an analysis of the pump's morphology indicates that it functions like a reversible bellows. Contraction of the anterior pump's morphology indicates that it functions like a reversible bellows. Contraction of the anterior pump retractors with the cibarial valve open (valve retractor muscles contracted) and posterior pump retractors relaxed (pump closed posteriorly) results in negative pump pressure and, hence, ingestion. Conversely, a wavelike posteroanterior relaxation of the pump retractors with the cibarial valve closed results in food being "swallowed" past the true mouth into the pharynx of the foregut.

HARRIS, K.F., Z. PESIC-VAN ESBROECK and J.E. DUFFUS. Morphology of the sweet potato whitefly, *Bemisia tabaci* (Homoptera, Aleyrodidae), relative to virus transmission. Zoomorphology 116:143-156. 1996.

The stylet bundle of the sweet potato whitefly, *Bemisia tabaci*, consists of paired mandibles and maxillae. The latter interlock to form the food and salivary canals. Its salivary system consists of paired primary and accessory glands in the thorax. Primary and accessory gland ducts on each side of the nerve cord fuse to form lateral ducts that course anteroventrally to the midline and continue to parallel down the hypopharynx to eventually fuse to form the single afferent duct of the salivary pump. Saliva exiting the pump via the efferent duct enters the salivary canal of the maxillae. Food from the maxillary food canal passes from the antecibarium to the postcibarium or sucking pump and, per os, to the pharynx and esophagus of the foregut. The esophagus extends from the head to the base of the abdomen where it and the anterior midgut intimately mingle with the anterior hindgut to form a filter chamber. The midgut then proceeds dorsocaudally before looping anteroventrally to join the hindgut. The latter gives off two fingerlike Malpighian tubules before entering the filter chamber, whence it proceeds dorsocaudally to the anus within the vasiform orifice. Where possible, the morphology of *Bemisia* is discussed in relation to plant virus transmission and the morphologies of more thoroughly studied homopteran vectors such as aphids and leafhoppers.

HARRIS, K.F., Z. PESIC-VAN ESBROECK, and J.E. DUFFUS. Preparation of whole insects for combined light and electron microscopy and immunocytochemistry. Silverleaf Whitefly: 1996 Supplement to the Five Year Plan. U.S. Dept. Agr. ARS No. 1996, pg. 35. 1996.

The following protocol is presented as a less expensive (equipment-wise) alternative to UV-cold polymerization of LR White. In our laboratory, the protocol has yielded high-quality embeddings of whole insects, the sweet potato whitefly *Bemisia tabaci* Gennadius, with excellent trimming and sectioning characteristics for both light and electron microscopy. Additionally, polymerization at a more moderate temperature (55°C) preserves antigenicity for immunocytochemistry. The latter was an important consideration since we wanted to study the fate of whitefly-borne plant viruses both in the vector and plant hosts.

The chamber for replacing air with dry, nitrogen gas (N<sub>2</sub>) is built using 3/8 in-thick plexiglass panels. However, other air tight containers such as a modified preserve jar ought to work well too (Harris et al., 1995, Microsc. Res. Tech. 33:264-265). A tank of dry N<sub>2</sub> gas, fitted with pressure and flow rate valves, was connected to the chamber inlet line with polyethylene tubing. Polyethylene tubing from the exit line was inserted into a 2-liter flask half-full with water for both visual and audible (bubbling) monitoring of the gas

flow through the tank. With both chamber valves fully open, a flow rate of 10 ft<sup>3</sup>/h was chosen as one that replaced the air in the chamber at a reasonably fast rate while creating minimal turbulence in the chamber. At this rate of flow, the chamber-volume replacement rate (CVRR) is greater than two chamber vol/min. Therefore, assuming perfect mixing of the gases, greater than two thirds of the existing gas in the chamber would be displaced each min, thus reducing the air in the chamber by more than one third each min. The approximate fractions of the gas in the chamber that are air and dry N<sub>2</sub> after any 10 min are (1/3)10air + [1-(1/3)10]N<sub>2</sub> or 0.0000169 air + 0.9999831 dry N<sub>2</sub>. Even using a conservative CVRR of 1 chamber vol/min, the percent N<sub>2</sub> by volume in the chamber after 10 min, [1-(1/2)10] X 100, would still be >99.99%. By applying Boyle's Law, it was determined that the nitrogen in the closed chamber would be raised to ca. 1.6 psi above atmospheric pressure at the polymerization temperature of 55°C. Our chamber tested leakless up to 5 psi.

Whiteflies are fixed in 3% paraformaldehyde and 0.5% glutaraldehyde in 0.1 M Sørensen's buffer, Ph 7.2, for 1-2h, given two 15-mm rinses in the same buffer, dehydrated in ethanol (15 min in 50% followed by 15 min in 70%), infiltrated for 1 h on a rotary mixer (Ted Pella, Inc.) with a 2:1 dilution of LR White (medium grade, EMS) and 70% ethanol followed by three changes in 100% LR White for 1 h, overnight, and 8 h, respectively. The insects are then transferred to flat, polyethylene EFLA embedding molds (Ernest F. Fullam, Inc.) filled with "nitrogen-infused" 100% LR White. The molds are topped off, covered with Aclar® embedding film (Ted Pella, Inc.) and placed in the polymerization chamber which is then sealed and flushed with N<sub>2</sub> for 10 min at a flow rate of 10 cfh. Blocks are trimmed and sectioned with glass or diamond knives on a porter-Blum MT2-B ultramicrotome. For light microscopy, sections are transferred to droplets of filtered water of glass slides coated with 0.01% poly-L-lysine (Sigma), dried at 40°C, stained with methylene blue and basic fuchsin, and viewed and photographed under a Zeiss Standard 25 compound microscope. Light microscopy also enabled us to study *Bemisia's* internal morphology and to choose areas of specimens for ultrathin sectioning and immunocytochemistry. Antigenicity is preserved by lowering the polymerization temperature to 55°C. Virus particles have been localized both in the vector and virus-infected plants using immunogold-silver staining followed by light and electron microscopy.

While establishing the present protocol, many abbreviated versions were tested. That testing led us to conclude that each and every step of the protocol ("infusing" the liquid resin with N<sub>2</sub>, evacuating or degassing the N<sub>2</sub>-infused resin, covering the mold with Aclar®, and polymerizing the resin in a nitrogen atmosphere) is essential to consistently obtaining high-quality embeddings at a polymerization temperature of 55°C. We have processed whole-insect specimens on more than a dozen occasions since adopting this oxygen-free polymerization protocol. To date, all blocks obtained have had excellent trimming and sectioning characteristics. Serial sectioning of whole insects is now not only possible but routine.

HARRIS, K.F. Z. PESIC-VAN ESBROECK and J.E. DUFFUS. Whitefly morphology and virus-vector interactions. Proc. Bellagio Whitefly Conference "Whiteflies and Viruses: Menace to World Agriculture," p. 13. 1996.

The whitefly feeding apparatus is comprised of six exoskeletal lobes: the clypeolabrum anteriorly, paired lora anterolaterally, paired maxillary plates posterolaterally, and the hypopharynx posteriorly. Another lobe, the labium, emerges from the cervical venter. The cibarium, is divided by cibarial valve into antecibarium and postcibarium, the latter functioning as a "sucking" pump. The noncellular, cuticular walls of the cibarium and the origin of its valve and pump retractor muscles from the anteclypeus and postclypeus, respectively, attests its evolutionary linkage to the preoral orthopteroid cibarium. The mouth between the cibarium and the pharynx of the foregut coincides with the frontoclypeal suture and the distal-most descent of the frontal ganglion. Similarities among their feeding apparatuses further

confirm that homopteran vectors acquire noncirculative viruses during intracellular ingestion and carry them externally or "internally" on the cuticular surfaces of the feeding apparatus: "cuticulaborne."

Others concluded that homopterans cannot egest and that they inoculate noncirculative viruses by "extravasation" (Ammar and Nault, 1991). But extravasation, a highly specialized term inappropriately taken from medical pathology, misleadingly links virus transmission to an unpredictable, abnormal, passive, vector activity. We propose the exact opposite: Noncirculative transmission is linked to the predictable, normal, active, functional, vector activities of ingestion and egestion, the homopteran feeding apparatus is equally equipped for both. Aphids, leafhoppers and, by morphological similarity, whiteflies can sustain negative or positive pressure in the pump chamber for prolonged periods during which the chamber fills (ingestion) or empties (either egestion or "swallowing"), respectively. Contraction of the anterior pump retractors with the cibarial valve open (valve retractor muscles contracted) and posterior pump retractors relaxed (mouth closed) results in negative pump pressure and, hence, ingestion. Conversely, a wavelike posteroanterior relaxation of the pump retractors with the valve open results in egestion. And a wavelike anteroposterior relaxation of the pump retractors with the cibarial valve closed and the mouth open results in food being "swallowed" into the pharynx of the foregut. This reversible, bellowslike functioning precludes egestion of virus from the pharynx, thus rendering "foregut-borne" (Nault and Ammar, 1989) a misnomer.

KARASEV, A.V., O.V. NIKOLACVA, J.E. DUFFUS, R.F. LEE, and W.O. DAWSON. Beet yellow stunt virus coat protein gene: expression in vivo and in vitro. Phytopathology (In press). 1997.

Beet yellow stunt virus (BYSV) has flexuous, thread-like virions 1400 nm long composed of a coat protein (CP) of approximately 24-kDa. The genome of BYSV encodes at least 9 open reading frames (ORFs) which code for proteins ranging from 6 to 66-Kda. Based on amino acid sequence comparisons, the CP gene was identified as a protein product of the ORF7. There are two ORFs between the ORF7 and the 3' terminus, and thus the respective subgenomic (sg) RNA expressing BYSV CP is about 1700 bases long. The dsRNA species corresponding to the BYSV CP sgrNA was used for the selective RT-PCR amplification of the 5'-terminus of the sgrNA. The CP-encoding sgrNA has an AT-rich, 66-nt long untranslated region (UTR). Like sgrNAs of other closteroviruses, this CP gene UTR starts with an A. ORF7 was cloned into a pMAL bacterial expression vector, the resulting fusion protein was affinity-purified and used as an antigen to generate anti-BYSV-CP antiserum in guinea pigs. The antiserum raised had a titer of  $10^5$  in immunoblots and easily detected the 23.8-kDa BYSV CP in sowthistle plants 3 weeks postinfection.

LEWELLEN, R.T. Comparison of two sources of resistance to rhizomania and associated high temperature root rots in sugarbeet. J.SugarBeet Research. (In press). 1997.

Under severe rhizomania, Rz (Holly factor) provides only intermediate levels of resistance. Higher levels of resistance appear to be available from an enhanced sugarbeet x *Beta vulgaris* spp. *maritima* population developed at Salinas. This population called R22 was originally released as C50 and subsequently released as C51 after multiple cycles of selection for resistance to rhizomania. Backcross derived sugarbeet breeding lines in multigerm and monogerm backgrounds also were released as C79-8 and C890-8. In ongoing breeding work these C51 type lines have given high levels of protection against severe rhizomania and associated root rots. Tests were run in overwintered trials in Imperial Valley to compare resistance conditioned by Rz and C51 factors. Three hybrids were compared in May (moderate temperature) and July (high temperature) harvests grown with and without rhizomania. The hybrids were (i) a susceptible commercial, (ii) Rz experimental, and (iii) C51

experimental (25% *B.v.m.* germplasm). Without rhizomania, the susceptible commercial had the highest sugar yield and C51 hybrid the lowest. With rhizomania the opposite occurred. The Rz hybrid was intermediate in both situations. The C51 hybrid had the least root rot and plant loss. For the three hybrids harvested in May, the sugar yield losses were 43,34, and 12%, respectively. In July under extremely high temperatures, the sugar yield losses were 70,44, and 28% and root rot killed 40,13, and 4% of plants. These results suggest that these resistance sources did not fully protect against rhizomania, but that resistance from C51 was stronger than from Rz factor. However, in these hybrids the resistance factors at best were heterozygous and fewer than 100% of the plants carried resistance. In addition, some losses across all hybrids may have been caused by other soil-borne problems (e.g. cyst nematode) that increase when rhizomania infested test areas are established.

Lewellen, R.T. Registration of Sugarbeet Germplasm Lines C78, C80, and C82. Crop Sci. 37. (In press). 1997.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C78 (PI 593671), C80 (PI 593672), and C82 (PI 593675) are diploid ( $2X = 18$ ), multigerm, self-sterile, and segregate for hypocotyl color. They combine multiple disease resistance and segregate for resistance to rhizomania (Rz), caused by beet necrotic yellow vein virus. These lines were developed from three of the primary base populations that have been developed in the virus yellows and multiple disease resistance program at Salinas. C78, C80, and C82 were released in 1994. With line improvement and progeny evaluation procedures, it should be feasible to extract parental lines from this material relatively quickly to obtain various combinations of disease and bolting resistance and traits for productivity.

C78 is genetically similar to C46 except that it has resistance to rhizomania. It was developed using C46/2 as the BC<sub>1</sub> through BC<sub>3</sub> recurrent parent. C37 was used to make the F<sub>1</sub> in a cross to a Holly Hybrid Rz source. Following BC<sub>3</sub>, the line was increased five times. For three of these increases, recurrent phenotypic selections were made for resistance to rhizomania, including one cycle of selection for combined resistance to rhizomania, virus yellows caused by beet yellows and beet western yellows viruses and *Erwinia* root rot. The final cycle of selection was for resistance to bolting. From 12 month old plants in an overwintered planting, nonbolted plants were selected. Within these nonbolted plants, a reselection was made based upon individual root sucrose concentration. C78 has been evaluated as breeding lines similar to R678, R578, R478NB, R378, R278, and R278Y.

C80 is similar to C54, a broadbased population released in 1988, but will segregate for resistance to rhizomania. C54 was developed as line Y54 in the multiple disease resistance program. It was derived from composite crosses among six breeding lines that collectively comprised germplasm from C37, 45%, C663, 32%, and C01, 23%. Except for the choice of C54 as the recurrent parent, C80 was developed similarly to C78 but underwent a different selection procedure for the last two cycles of selection. After two cycles of recurrent phenotypic selection for resistance to rhizomania, half-sib families were generated. Ninety-six families were tested at Salinas in trials grown under nondiseased, virus yellows, *Erwinia*/powdery mildew infected, rhizomania, and bolting conditions. Based upon yield, disease and bolting data, eight families were selected, increased, and topcrossed onto a common monogerm tester and evaluated for hybrid performance. The second synthesis of each of these eight half-sib families was planted into a field infested with rhizomania and at 3 months of age inoculated with *Erwinia*. At 7 months, mother roots within five of the families were selected based upon resistance to rhizomania and *Erwinia* and then reselected based upon sugar concentration. These roots were intercrossed in a seed increase plot to produce C80. C80 has been evaluated as breeding lines R680-#, R580-#, and R480-#.

C82 is a selection and recombination of lines similar to C76-43 and C76-89

released in 1993. Following three backcrosses of rhizomania resistance into C31/6, an advanced line from C31, line R76 was developed. The third cycle synthesis of R76 selected for resistance to rhizomania was crossed to C31-43 and C31-89 to produce breeding lines R76-43 (C76-43) and R76-89 (C76-89). These two lines were grown in an overwintered nursery to evaluate and select for nonbolting tendency. Twelve month old, nonbolted mother roots were selected from each line and then reselected for high sucrose concentration. These mother roots were intercrossed in an isolated seed increase to produce C82. C82 is being evaluated as line R482NB and is similar in performance to breeding lines tested as R681, R581, and R484.

LEWELLEN, R.T. Registration of sugarbeet germplasm lines C79-1 to C79-11 with resistance to rhizomania. Crop. Sci. 37 (In press). 1997.

Sugarbeet (*Beta vulgaris* L.) germplasm lines C79-1 through C79-11 (PI 593660 to PI 593670) were released in 1994. C79-1 through C79-11 are lines with a C37 genetic background and resistance to rhizomania, caused by beet necrotic yellow vein virus (BNYVV). Each line in the C79 series involved a different initial nonrecurrent source that was known or had been identified as having resistance to rhizomania. C37 was chosen as the common recurrent parent because of its adaptation to the western USA. C37's high self-sterility and homozygous green hypocotyls facilitated making and identifying backcrosses. Extractions from breeding lines similar to C37 have been used widely as parental lines in commercial hybrids. C37 is a closely bred, diploid, multigerm line with good resistance to curly top virus, *Erwinia* root rot and bolting. C37 is tolerant to virus yellows, caused by beet western yellows and beet yellows viruses. It is uniformly susceptible to rhizomania. Except for resistance to rhizomania, C79 lines should be genetically similar to C37. Lines in the C79 series will segregate for resistance to rhizomania. Because rhizomania resistance was traceable through the backcrossing procedure, it is thought that major resistance is dominant and usually monogenic. Minor and modifying genes may have been lost during the backcross procedure. In general, it was observed that with each backcross to C37, line vigor, and to some degree resistance to rhizomania, appeared to become diminished based upon field trial results.

Rhizomania susceptible, green hypocotyl plants of C37 were used as the female recurrent parent. Crosses were made under paper bags as pair plant crosses in the greenhouse. Seed produced on C37 was harvested separately and bulked. From 16 to 24 crosses were made per source per backcross.  $F_1$ 's were identified by either hypocotyl color and/or resistance to rhizomania. Selections for resistance were made in 4 month old plants grown in uniformly BNYVV infested field plots. Plots were usually sown in early August after seed had been produced and processed in the early summer. Resistant plants were selected in the field in early December based upon absence of root symptoms, root size and shape, and freedom from bolting. Under these mild fall conditions, escapes were sometimes inadvertently selected.

The original source of resistance included sugarbeet, Swiss chard, weed beet, and wild beet (*B. vulgaris* spp. *maritima* L.). This series of lines is being released as potentially new sources of resistance to rhizomania. The allelism or relationship among these sources has not yet been determined.

LI, R.H., G.C. WISLER, H.-Y. LIU and J.E. DUFFUS. Comparison of diagnostic techniques for detecting tomato infectious chlorosis virus. Phytopathology 86:512-513. 1996.

A polyclonal antiserum prepared against purified virions of tomato infectious chlorosis virus (TICV) was used to determine the distribution of the virus in infected plants, to detect the virus in field samples, and to study relationships among TICV isolates. A cRNA probe representing TICV RNA 1 and RNA 2 was also used in dot-blot hybridization tests. TICV was detected in



leaf, stem, flower, fruit and root tissues of the infected tomato plants. The virus was not uniformly distributed throughout the infected tomato plant, but a higher virus concentration was observed in fully developed tomato leaves at the onset of yellowing symptoms. The virus was detected both in whitefly (*Trialeurodes vaporariorum*)-transmitted tomato, tomatillo, potato, and *Nicotiana clevelandii* and in naturally infected tomato, petunia, primrose, and *Ranunculus* sp. collected from commercial seed companies using Western blot analysis, indirect ELISA, and dot-blot hybridization. The comparative study of these three techniques indicated their similar sensitivities for TICV detection. Based upon these tests, there were no detectable serological or nucleic acid differences among three TICV isolates collected from Orange and Yolo Counties of California and from Italy.

LI, R.H., G.C. WISLER, H.-Y. LIU and J.E. DUFFUS. Partial nucleotide sequence analysis of tomato infectious chlorosis virus (TICV). *Phytopathology* 87: (In press). 1997.

TICV RNA genome was cloned as cDNA generated from genomic RNA extracted from purified virus. The sequence of the 4516 nt of RNA 1 and of the 2963 nt of RNA 2 was determined. The sequenced portion of RNA 1 includes three open reading frames (ORFs) potentially encoding (5' to 3') proteins with the molecular mass of 58 kDa (ORF1b) and 27kDa (ORF2), and a potential noncoding region of 116 nt. The TICV 58 kDa protein is an RNA-dependent RNA polymerase (RdRp) which is very similar to those of other closteroviruses. The 27 Kda protein of unknown function contains a thiol-protease motif near the C-terminus. The partial sequence of ORF1a encodes the C-terminal 709 amino acids of a polypeptide containing a methyltransferase and a helicase. The sequenced portion of RNA 2 is composed of two ORFs which are analogues of ORF6 (CP duplicate) and ORF7 (p26) of lettuce infectious yellows virus (LIYV). They potentially encode proteins of CP duplicate (70 KDA) and p27 of unknown function, respectively. Based on computer-assisted analysis of the available sequence data of both RNAs on the sizes and ORF organization, TICV is more closely related to LIYV than to other closteroviruses.

LIU, H.-Y., J.E. DUFFUS, and G.C. WISLER. Etiology of vascular necrosis syndrome of sugarbeet. Intern. Working Group on Plant Viruses with Fungal Vectors, Dundee, Scotland, pp. 161-164. 1996.

A vascular necrosis syndrome (VNS) of sugarbeet has been observed in the Imperial Valley of California. The incidence of VNS can be up to 80% in some fields. No evidence of fungi, bacteria or mycoplasma-like organisms has thus far been implicated in the syndrome. Three soil-borne viruses, tomato bushy stunt virus (TBSV), tobacco necrosis virus (TNV), and tobacco mosaic virus (TMV) have been isolated from sugarbeet roots with VNS. The infectious agents have been purified and antisera produced. An inoculation procedure developed for TBSV resulted in beets that showed yellowing and stunting symptoms. However, no symptoms of VNS have been produced to date. Attempts to inoculate TNV to beets have failed. At this point the causal agent or agents of VNS are not known.

LIU, H.-Y., R.H. LI, G.C. WISLER and J.E. DUFFUS. Characterization of Abutilon Yellows Virus - new Clostero-like virus transmitted by the banded wing whitefly. *Phytopathology* 87: (In press). 1997.

A virus, first discovered on velvetleaf (*Abutilon theophrasti*) in Illinois, has been maintained in greenhouse culture since 1977. Recent studies on the virus, designated as abutilon yellows virus (AYV), have shown that leaf dips and purified preparations contained long, flexuous, filamentous particles approximately 850-900 x 12nm. The virus was transmitted by the banded-wing whitefly (*Trialeurodes abutilonea*) in a semipersistent manner and retained by the vector for four days. The virus has an apparently narrow host range and

could not be mechanically transmitted. Inclusion bodies, characteristic of closteroviruses, were consistently associated with the phloem of AYV-infected *Nicotiana clevelandii*. Abutilon yellows virus was cloned with dsRNA isolated from AYV-infected *N. clevelandii* as a template. These clones specifically reacted with dsRNA, as well as with total nucleic acids extracted from AYV-infected plants in dot blot analyses. No reactions were observed in dot blots against uninfected host plants and other known whitefly transmitted closteroviruses.

PESIC-VAN ESBROECK, Z., K.F. HARRIS, and J.E. DUFFUS. Sweetpotato whitefly - squash leaf curl virus immunocytochemistry. Silverleaf Whitefly: 1996 Supplement to the Five Year Plan. U.S. Dept. Agr. ARS No. 1996, pg. 40. 1996.

Colonies of *B. tabaci* were maintained in a climate-controlled insectary in cages in growth cabinets under 16h of daylight, 60% relative humidity, and day and night temperatures of 29° and 26°C, respectively. Viruliferous whiteflies were maintained on squash seedlings infected with SLCV, whereas virus-free cultures were reared on sweet potatoes (*Ipomoea batatas* L.).

*Specimen preparation at room temperature.* SLCV-infected squash leaves and adult female and male whiteflies were processed as previously described (Harris et al., 1995, *Microsc. Res. Tech.* 33:264-265). In order to enhance fixative penetration, whole insects were submerged in 0.1 M. Sørensen's buffer, Ph 7.2, and legs and wings were removed with fine forceps under the stereomicroscope. Whiteflies were fixed in 3% paraformaldehyde and 0.5% glutaraldehyde in Sørensen's buffer for 1.2-2h on a rotary mixer. After two 15-min rinses in Sørensen's buffer, insects were dehydrated in a graded ethanol series, 15 min in 50% followed by 15 min in 70% ethanol, infiltrated for 1 hr on a rotary mixer with a 2:1 dilution of LR White and 70% ethanol, followed by three changes in complete LR White for 1h, overnight and 8h, respectively. The insects were transferred to flat polyethylene embedding molds, filled with nitrogen-infused complete LR White and polymerized in a nitrogen polymerization chamber for 48 h at 55°C. Blocks were sectioned with glass or diamond knives on a Porter-Blum MT2-B ultramicrotome.

Immunocytochemistry, semithin sections, about 1 µm thick, were mounted in a drop of water on glass slides coated with 0.01% poly-L-lysine, dried at 40°C, stained with the silver, poststained with methylene blue and basic fuchsin, and viewed and photographed under a Zeiss Standard 25 compound microscope. For TEM, ultrathin sections (60-90 nm) were collected onto formvar-coated nickel grids and floated face down (15 min) on drops of 0.02M glycine in Tris-buffered saline, transferred for 20 min to blocking buffer, incubated in SLCV antiserum, rinsed in blocking buffer, transferred to immunoglobulin-gold complex, rinsed first in blocking buffer then water and stained with uranyl acetate and lead citrate. Virus-exposed whiteflies used as controls in this study were subjected to nonimmune rabbit serum or blocking buffer or antiserum to lettuce infectious yellows virus, as the substitute for the primary antibody, prior to immunogold labeling. Virus-free whiteflies were first exposed to SLCV antibodies followed by immunogold labeling. SLCV was localized by IGSS-LM and IGL-TEM in the following systems and organs of viruliferous whiteflies: digestive system (esophagus, filter chamber, midgut and hindgut), excretory system (malpighian tubules), hemocoel, mycetome (mycetocytes), fat body (fat cells), reproductive system (follicular cells and oöcytes) and salivary system (primary and accessory glands and their duct systems). Gold label was not present in virus-exposed controls or immunotreated virus-free controls.

Virus invades numerous organs and tissues in its passage from the maxillary food canal in the feeding apparatus (acquisition) to the ducts of the salivary gland system (inoculation). In the digestive system virions are capable of penetrating the intima and epithelium of the foregut to directly enter the hemocoel in close proximity to the salivary glands. The latter might explain



the short latent periods observed for geminivirus transmission. After penetrating the basal laminae of the salivary glands, virions move into cisternae formed by infolding of the basal plasmalemma. Specific attachment of virus particles of the surface of this dynamic, membrane system enables virions to be carried by membrane flow to microvillous canaliculi formed by the infolded apical plasmalemma and, by exocytosis, into the salivary duct lumen. The presence of gold label and virus particles around and in nuclei of affected cells of several organs (follicular cells, oöcytes, mycetocytes, and epithelial cells) and gross as well as ultrastructural abnormalities of affected organ systems (reproductive, digestive and excretory systems) suggest that SLCV may multiply in one or more tissues of its vector.

PETERSEN, M.A., G.C. WISLER, D.E. PURCIFULL and J.E. DUFFUS. Cytopathology of infections caused by the whitefly-transmitted lettuce chlorosis closterovirus. Phytopathology 86:571. 1996.

Lettuce chlorosis virus (LCV) is a closterovirus which is transmitted by *Bemisia tabaci* and is found in southwestern desert regions of the U.S.A. (Duffus et al., Eur. J. Plant Pathol., in press). Electron microscopy of thin sections from leaf tissues of *Nicotiana clevelandii* and *Lactuca sativa* infected with LCV revealed that some phloem cells of both hosts exhibited the following symptoms: numerous cytoplasmic vesicles, proliferated endoplasmic reticulum, degenerated, vesiculated mitochondria, and some vesiculation of chloroplasts. Aggregates of vesicles were sometimes large enough to occupy much of the cell, and often small clusters of these vesicles were bound by a single unit membrane. Mitochondria showed degeneration which ranged from mild disorganization of cristae to individual mitochondria appearing as small groups of vesicles bound by a double unit membrane. These changes are consistent with reports of the cytopathology caused by other closteroviruses.

SIMONE, G.W., R.C. HOCHMUTH, G.C. WISLER, J.E. DUFFUS, H.-Y. LIU, and R.H. LI. New Whitefly-vectored closterovirus of tomato in Florida. 1996 Proc. Florida Tomato Institute, pp. 71-74. 1996.

A new viral-caused disease of tomato was identified in January 1996 from the greenhouse-grown tomato industry in north central Florida. This virus represents a previously undescribed member of the Closterovirus genus of viruses and has been designated Tomato Chlorosis Virus (ToCV) (10). This diagnosis has finally provided an answer for the long-standing tomato malady known as "yellow leaf disorder" that has existed in greenhouse-tomato production sites within Florida since as early as 1989 (unpublished data, G.W. Simone).

The greenhouse vegetable industry comprised some 66 acres of production in 1991, 32% of which was tomato production (7). These sites are scattered throughout Florida from Escambia county in the northwest to Dade county in the southeast. The appearance of "yellow leaf disorder" between 1989-1995 was generally correlated to use of a contaminated fungicide (or its residual action) by most growers. Observation of "yellow leaf disorder," however, in field tomato production in north Florida and in new greenhouse production sites without a history of the suspect fungicide seemed to negate the toxic fungicide explanation for this malady. No examination of nutrient levels by direct analysis or through plant tissue analysis revealed any significant macro- or minor element imbalances. The potential occurrence of autogenous necrosis in particular tomato cultivars (8) was pursued and discounted. Examination of plant samples for plant pathogens was also repeatedly negative. Such techniques as plant virus inclusion examination by light microscopy, electron microscopy, serology and mechanical transmission to bioassay host plants yielded no evidence of plant viruses.

The active research by USDA-ARS scientists at Salinas CA on a new closterovirus of tomato (Tomato Infection Chlorosis Virus - TICV) prompted submission

of symptomatic plant samples from Florida to the USDA-ARS staff in January 1996. Utilizing the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), successful transmission of the unknown agent into *Physalis wrightii* and *Nicotiana clevelandii* spp. was obtained (10). These species proved to be superior hosts for the virus, allowing detection of long flexuous rods conforming to the size range of a Closterovirus.

TIAN, T., V.A. KLAASSEN, J. SOONG, G. WISLER, J.E. DUFFUS and B.W. FALK. Generation of cDNAs specific to lettuce infectious yellows closterovirus and other whitefly-transmitted viruses by RT-PCR and degenerate oligonucleotide primers corresponding to the closterovirus gene encoding the heat shock protein 70 homolog. *Phytopathology* 86:1167-1173. 1996.

Oligonucleotide primers were designed based upon nucleotide sequences corresponding to the conserved phosphate 1 and phosphate 2 motifs contained within the closterovirus-encoded heat shock protein 70 (HSP70) homolog. These primers were used with RNAs extracted from virus-infected plants and the reverse transcriptase polymerase chain reaction (RT-PCR) to generate specific cDNAs for lettuce infectious yellows closterovirus (LIYV), and for four additional whitefly-transmitted viruses for which corresponding nucleotide sequence data were unavailable. These included tomato infectious chlorosis virus (TICV), cucurbit yellow stunting disorder virus (CYSDV), beet pseudo-yellows virus (BPYV) and lettuce chlorosis virus (LCV). The resulting ca.600 nt cDNAs corresponding to LIYV, TICV, CYSDV and BPYV were cloned and the nucleotide sequences were determined. Computer-assisted analysis of the deduced amino acid sequences showed that all exhibited significant similarity to the HSP70 proteins in general, and to the HSP70 homologs encoded by closteroviruses in particular. Comparative alignments showed that the amino acid sequences for LIYV, TICV, BPYV and CYSDV sequences were more similar to each other than to the corresponding regions for the HSP70 homologs of three aphid-transmitted closteroviruses. Digoxigenin-UTP-labeled transcripts were generated from each cloned cDNA and used in RNA and dot blot hybridization analyses. Probes for LIYV, TICV, BPYV and CYSDV hybridized only with dsRNAs or extracts of plants infected with the corresponding virus.

WIDNER, J.N., G.C. WISLER, J.E. DUFFUS, and J.L. SEARS. A new report of rhizomania and other furoviruses infected sugar beet in Minnesota. Part I: field observations. *J. Sugar Beet Research* (In press). 1997.

Several sugar beet fields in the Southern Minnesota Beet Sugar Cooperative growing area showed patches of unusual pale greenish-yellow foliage in early August that did not resemble other known disorders. The roots from these areas showed various degrees of sprangling, stunting, and proliferation of feeder roots. Serological evaluations of suspect roots showed positive infection of Rhizomania, caused by the beet necrotic yellow vein virus (BNYVV) and other furoviruses. The distribution of infected fields was not isolated to any general area, which indicates that the virus has been present and multiplying in previous sugar beet crops. Severity of infection ranged from mild symptoms with near normal yields and sugar content to moderate to severe root stunting and low sugar content.

WISLER, G.C. and J.E. DUFFUS. Epidemiology and ecology of whitefly-transmitted closteroviruses. *Proc. 10th Intern. Congr. of Virology - Jerusalem*, p. 89. 1996.

Agriculturists have been deficient in recognizing interveinal yellowing or reddening in crops induced by closteroviruses as distinct from natural factors such as aging, soil moisture, and fertility. Increases in whitefly populations over the past decade has led to the recognition of a new subgroup of whitefly-transmitted closteroviruses. Some of these viruses are lettuce infectious yellows (LIYV), tomato infectious chlorosis (TICV), lettuce

chlorosis (LCV), cucurbit yellow stunting disorder (CYSDV), sweet potato sunken vein (SPSVV), and beet pseudo yellows (BPYV). With the exception of TICV and BPYV, which are transmitted by *Trialeurodes vaporariorum*, the others are transmitted by *Bemisia tabaci* or *B. argentifolii*. The biology and ecology of the whitefly vector and the range of weed and agronomic hosts significantly affect the epidemiology of these new closterovirus diseases. For example, until LIYV was eliminated from the Imperial Valley of California, LCV, which induces identical symptoms on lettuce, was not detected. The elimination of LIYV was brought about by the destruction of the melon crops by *B. argentifolii* feeding. The incidence and importance of LCV in lettuce and the role of alternate weed and agronomic hosts have not been determined. Information regarding vector biology, genome organization, vesicle formation, and particle length will not only help us to better classify these organisms, but will ultimately aid in detection and diagnosis of these viruses and their control.

WISLER, G.C., J.E. DUFFUS and J.S. GERIK. First report of lettuce chlorosis virus naturally infecting sugarbeets in California. Plant Disease Notes (In press). 1997.

Sugar beet (*Beta vulgaris*) plants showing interveinal yellowing and thickened leaves were collected from two fields in Imperial County, CA. for disease assessment in January 1996. Yellowing symptoms were wide spread in these fields during the winter of 1995 to 1996. Initial enzyme-linked immunosorbent assays (ELISA) with polyclonal antiserum (ATCC) for beet western yellows virus were consistently negative. Inoculations with *Bemisia tabaci* "B" biotype (*B. argentifolii*) whiteflies onto the indicator plants *Chenopodium capitatum*, *C. murale*, lettuce (*Lactuca sativa*), and sugar beet resulted in interveinal yellowing, reddening, and thickened leaves characteristic of whitefly-transmitted closteroviruses (1). Western blot (immunoblot) analyses were performed with antisera to the purified virions of lettuce chlorosis virus (LCV) and lettuce infection yellows virus (LIYV). Tissue extracts from original beet plants representing two fields and from all subsequent whitefly-inoculated indicator plants consistently showed a single band at ca. 32 kDa, reported to be the molecular mass for LCV capsid protein (2). Corresponding Western blot analyses for LIYV with the same tissue extracts were negative. No reactions were observed in Western blot assays with tissue extracts from healthy plants. Although sugar beet is a host for LCV as shown by laboratory experiments (1), this is the first report of a natural infection of LCV in sugar beet.

WISLER, G.C., J.E. DUFFUS, H.-Y. LIU, R.H. LI and B.W. FALK. Tomato infectious chlorosis virus--a new whitefly-transmitted tomato virus in California. Calif. Agric. 51:24-26. 1997.

A new virus of tomato, tomato infectious chlorosis virus (TICV), has been identified in both field- and greenhouse-grown tomatoes in California, North Carolina and Italy. TICV is transmitted by the greenhouse whitefly (*Trialeurodes vaporariorum*) in a semipersistent manner. TICV infects a wide range of plant hosts, and has been found naturally infecting *Petunia* and *Ranunculus* in greenhouses, and tree tobacco, commercial artichoke and bristly oxtongue in the southern coastal region of California. Because of its wide host range, the prevalence of the greenhouse whitefly in fields and greenhouses, and the movement of susceptible plant hosts within and among countries around the world, TICV is a potential problem for the world's tomato industry. TICV caused an estimated \$2 million loss in Orange County in 1993. Control measures include whitefly control, confirmation of TICV infection by a diagnostic test and roguing of infected plants.

WISLER, G.C., J.E. DUFFUS, H.-Y. LIU, R.H. LI, G.W. SIMONE and R.H. HOCHMUTH. A new whitefly transmitted virus infecting tomato from Florida. Phytopathology 86:571-572. 1996.

A previously undescribed virus of greenhouse grown tomatoes from Suwannee, Alachua, and Marion counties of Florida has been identified. This virus is transmitted by *Trialeurodes vaporariorum*, *Bemisia tabaci*, and *B. argentifolii*, and is not mechanically transmissible. Symptoms in tomato (interveinal yellowing and necrosis), *Physalis wrightii*, and *Nicotiana clevelandii* are similar to those caused by the tomato infectious chlorosis closterovirus (TICV). The new virus reacted weakly against TICV antiserum in ELISA and western blots. Molecular probes to TICV RNA 1 and 2 do not react with the new virus in any host tested using dot-blot hybridization. Particles of this virus are slightly flexuous, with a normal length about 850 nm (over 100 particles measured). The dsRNA analysis of four Florida isolates indicate two RNA's with a slightly higher mobility than those of TICV in agarose and acrylamide gels. Inclusion bodies characteristic of the genus *Closterovirus* are located in the phloem tissue of infected plants and stain red-violet with Azure A. RT-PCR analysis using degenerate primers designed to amplify the HSP70 gene of closteroviruses did not amplify a product for the four Florida isolates in repeated tests. This is apparently a new virus of tomato distinct from TICV.

WISLER, G.C., R.H. LI, H.-Y. LIU, and J.E. DUFFUS. Partial molecular and cytological analysis of tomato chlorosis virus. *Phytopathology* 87: (In press). 1997.

Tomato chlorosis virus (ToCV) is distinct from tomato infectious chlorosis virus (TICV) based on differences in whitefly transmission and lack of cross-reactivity in dot blot hybridizations. Light and electron microscopic observations confirmed the phloem limitation of ToCV and presence of numerous cytoplasmic vesicles in phloem cells. Northern blot analysis of ToCV confirmed the presence of two major dsRNAs of ca. 7.8 and 8.2 kbp. The specificity of cDNA clones corresponding to RNA 1 and 2 were confirmed by sequence comparisons to lettuce infectious yellows virus and TICV. Three clones correspond to the methyltransferase coding region of RNA 1, and four correspond to the heat shock protein (HSP70) homolog of RNA 2. ToCV is a new member of the subgroup of bicomponent, whitefly-transmitted, phloem-limited viruses, and is the second distinct virus of this subgroup reported to infect tomatoes.

WISLER, G.C., R.H. LI, H.-Y. LIU, J.E. DUFFUS, G.W. SIMONE, R.C. HOCHMUTH and J.R. KNIGHT. Tomato chlorosis virus (ToCV) in a new closterovirus distinct from other whitefly-transmitted closteroviruses. *Phytopathology* 86:S118. 1996.

A new closterovirus was identified in greenhouse grown tomato plants in North Central Florida. The virus causes interveinal yellowing and necrosis in infected plants and reduces yield due to loss of photosynthetic area. This problem had been previously called "yellow leaf disorder" and was attributed to either pesticide phytotoxicity, physiological/nutritional disorders, or an unknown virus. This new virus, ToCV, is transmitted by four whiteflies, including the greenhouse (*Trialeurodes vaporariorum*), banded wing (*T. abutilone*), sweet potato (*Bemisia tabaci*), and silverleaf (*B. argentifolii*) whitefly. ToCV is similar to the previously described tomato infection chlorosis virus (TICV) with respect to symptomatology and dsRNA patterns in agarose gels, suggesting a bicomponent genome for ToCV like TICV. ToCV is distinct from TICV and other whitefly-transmitted closteroviruses based on limited serological cross-reactivity, and lack of reactions in molecular hybridization studies. Whereas TICV has been found in California, Italy, and North Carolina, ToCV has yet only been detected in Florida.

WISLER, G.C., H.-Y. LIU, R.H. LI, and J.E. DUFFUS. Comparative molecular analysis of several BNYVV- and BSBMV-related furoviruses infecting sugarbeet. Intern. Working Group on Plant Viruses with Fungal Vectors, Dundee, Scotland, pp. 53-56. 1996.

The relationships between five isolates of BNYVV from the United States and four isolates which are serologically identical to the BSBMV were evaluated based on the reactivity of molecular probes, the size and number of the RNAs, and polyadenylation. The BNYVV isolates were virtually identical to one another. The BSBMV-related isolates differed from each other by the size and number of RNAs, the reactivity with specific molecular probes, and different symptoms on indicator plants. All isolates tested were polyadenylated and had a least three RNAs. Thus, the BSBMV-related isolates, because of their polyadenylation and number of RNAs, more closely resemble BNYVV than the type member of the furovirus group, wheat soil-borne mosaic virus (WSBMV). It is suggested that these viruses of sugarbeet belong to the Benevirus group, as proposed by Dolja et al. (1994).

WISLER, G.C., H.-Y. LIU, R.H. LI, and J.E. DUFFUS. Partial characterization and diagnosis of the lettuce chlorosis virus of lettuce. Silverleaf Whitefly: 1996 Supplement to the Five Year Plan, U.S. Dept. Agr. ARS No. 1996, pg. 46. 1996.

A new closterovirus of lettuce, termed lettuce chlorosis virus (LCV) was separated from the yellowing complex of viruses in the desert southwestern United States in 1991. Symptoms of LCV on lettuce are very similar to those induced by lettuce infectious yellows virus (LIYV). However, LCV is readily distinguished from LIYV by lack of reciprocal serological cross-reactions, differences in susceptible hosts, and differences in whitefly vector efficiency. An important difference in host range between LCV and LIYV is the fact that LCV does not infect members of the Cucurbitaceae, whereas cucurbits are hosts of LIYV, and contribute significantly to its epidemiology. LIYV is transmitted efficiently by the A biotype of *Bemisia tabaci*, but inefficiently by the B biotype (*B. argentifolii*). In contrast, LCV is transmitted efficiently by both vectors.

Partial molecular analysis of LCV indicates that the virion RNA is ca. 8.0 kb, and the mobility of the dsRNA corresponds to the approximate size of the ssRNA in agarose gels. The virus has been purified, and antiserum has been prepared which reacts with LCV infected tissues in indirect-ELISA and western blot analyses. The coat protein from infected tissues and purified preparations is ca. 32 kDa. Measurements from over 250 flexuous, filamentous particles in leaf dips show a normal length of 800-850 nm and a width of 12 nm. A nonradioactive molecular probe has been prepared which also reacts with LCV infected tissues in dot blots and with virion RNA in Northern blot analyses, again showing a size of ca. 8.0 kb. This probe does not react with uninfected plant tissues or with LIYV, beet pseudo yellows virus, or tomato infectious chlorosis virus infected tissues.

Preliminary cytological analyses indicate that LCV is phloem limited and produces cytoplasmic vesicles. This information, in addition to particle morphology and vector specificity suggests the LCV is a member of the Closteroviridae.

WISLER, G.C., J.N. WIDNER, J.E. DUFFUS, H.-Y. LIU and J.L. SEARS. A new report of rhizomania and other furoviruses infecting sugar beet in Minnesota. Plant Disease 81:229. 1997.

Several fields planted in sugar beet (*Beta vulgaris*) in the Southern Minnesota Beet Sugar Cooperative growing area showed patches of pale greenish yellow foliage and upright leaves characteristic of rhizomania. Other symptoms included reduced root size and root proliferation. Samples taken from these

areas during August of 1996 were evaluated for beet necrotic yellow vein virus (BNYVV), the cause of rhizomania, and for other sugar beet furoviruses. BNYVV was identified in 59 of 90 beet samples tested with enzyme-linked immunosorbent assay and Western blot (immunoblot) analyses (molecular mass approximately 22 kDa) with specific (polyclonal antisera donated by K.Richards; monoclonal antisera donated by G.Grassi) and broadly reactive antisera produced at the USDA in Salinas,CA. Recovery by mechanical inoculation of *Chenopodium quinoa* and *Beta macrocarpa* confirmed identity. Beet leaves showing symptoms of vein clearing, vein banding, mosaic, and vein necrosis were all identified as being infected with beet soilborne mosaic virus (BSBMV). No systemic leaf symptoms of BNYVV were found in any sample. The BSBMV isolates were identical to one another based on symptomatology of indicator plants and molecular masses in Western blots (approximately 24 kDa), but symptoms were distinct from those of other members of the BSBMV serogroup isolates previously studied from Texas, Idaho, Nebraska, and Colorado. The beet soilborne virus, (BSBV) was also recovered by mechanical inoculation and Western blot analysis (antisera donated by R.Koenig) in three samples of field-collected beets. This is a new report of BNYVV, BSBMV, and BSBV in Minnesota. The distribution of rhizomania in infested fields was not isolated to any general area, which indicates that the virus has been present and multiplying in previous sugar beet crops and was not detected. Severity of infection ranged from mild root symptoms with near normal yields and sugar content, to moderate and severe root symptoms with low yields and low sugar content.

WISLER, G.C., J.N. WIDNER, J.E. DUFFUS, and J.L. SEARS. A new report of rhizomania and other furoviruses infecting sugar beet in Minnesota. Part II: laboratory analysis. J. Sugar Beet Research (In press). 1997.

Fields planted in sugar beet in Southern Minnesota showing patches of yellowing, upright leaves, reduced root size, and root proliferation characteristic of Rhizomania were evaluated for beet necrotic yellow vein virus (BNYVV) and other sugar beet furoviruses. ELISA tests and western blot analyses using both specific and broadly reactive antisera and recovery by mechanical inoculation of *Chenopodium quinoa* and *Beta macrocarpa* positively identified BNYVV in 59/90 beet samples tests. Beets showing leaf symptoms of vein clearing, vein banding, mosaic and vein necrosis were all identified as being infected with beet soil-born mosaic virus (BSBMV) only. No systemic leaf symptoms of BNYVV were found in any sample. The BSBMV isolates were identical to one another based on symptomatology of indicator plants and identical molecular weights in western blots (ca.24 Kda), but symptoms were distinct from other members of the BSBMV serogroup isolates previously studied from Texas, Idaho, Nebraska, and Colorado. The beet soil-borne virus (BSBV) was also recovered by mechanical inoculation and western blot analysis (antisera donated by R.Koenig) in three samples from field collected beets. This is a new report of BNYVV, BSBMV, and BSBV in Minnesota.

YU, M.H. Improvement of sugarbeet genotypes with root-knot nematode resistance. 29th ASSBT General Meet. Abstr., p. 56. 1997.

Sea beet, *Beta maritima* L., has the closest phylogenetic relationship with sugarbeet (*B. vulgaris* L.) when compared to any other beet species. The two *Beta* plants were proposed to combine into one species, simply by reclassifying sea beet as *B. vulgaris* subsp. *maritima* L. or *B. vulgaris* var. *maritima* L. Hybridization crosses between the two species are, thus, easily achievable via exchange of pollination bags. The sugarbeet root-knot nematode resistance, which was identified from rare occurring sea beet sources, has been transferred to sugarbeet through such approach. In the progeny population, phenotypic expression of certain undesirable sea beet characteristic remained. Nonetheless, the sprangled root structure and annual bolting traits have become less intense and sucrose content heightened as additional breeding efforts were built in. Further selection and improvement if underway to

develop sugarbeet genotypes with high levels of root-knot nematode resistance and productivity.

YU, M.H. Preliminary Observation of the First Identified Sugarbeet Root-Knot Nematode Resistance. Third Intl. Nematol. Congr. Abstr., p. 104. 1996.

Under *Meloidogyne* spp. infested conditions, sugarbeet (*Beta vulgaris*) plants generally suffered varied degrees of root gall and protuberance symptoms. A sea Beet (*B. maritima*) germplasm that segregated for resistance to root-knot nematode, *M. incognita* Race 1, has been identified. The nematode resistance was transmissible to sugarbeet and its hybrid derivatives through pollination in the greenhouse. Resistant plants were produced in progeny of interspecific hybridization, backcrosses, and self-pollination of resistant genotypes. Among the resistant progeny populations, one mutant leaf phenotype was discovered. Based on preliminary test results, this sea beet source was resistant to at least four species of root-knot nematode.

YU, M.H. Registration of Root-Knot Nematode Resistant Germplasm M66. Crop. Sci. 36:469. 1996.

M66 is a multigerm, self-fertile line derived from accession WB 66, designated PI 546387. M66 segregates for bolting, growth habit, and stem pigmentation. To screen for resistance, individual seedlings were grown in polyethylene containers. At the 4- to 6-leaf stage, they were inoculated with 1000 second-stage *M. incognita* Race 1 juveniles per plant and at 6 wk were examined for root gall and protuberance formations. In greenhouse tests, about 18% of seedlings derived from the initial accession were rated resistant. From the interpollination of plants selected for resistance, 42% of the progeny were resistant. When these resistant selections were crossed to nonresistant sugarbeet cultivars, about 23% were resistant. Resistance was based on individual test plants with 0 to 10 galls and/or protuberances per root system and with little or no detectable nematode reproduction. M66 is the pooled seed increased from WB 66 resistant plants. The nematode resistance derived from WB 66 is heritable. It will be of value as a source of root-knot nematode resistant germplasm for conducting sugarbeet breeding and root-knot nematode resistance studies.

## PAPERS PUBLISHED SINCE ABSTRACTED IN PREVIOUS REPORT

BECKER, J.O., A.F. WRONA, and R.T. LEWELLEN. Effect of solarization and soil fumigation on sugarbeet cyst nematode population, 1993-95. Biol. & Cult. Tests to Control Plant Disease 11:19. 1996.

DUFFUS, J.E. Whitefly-borne viruses. pp. 255-263 in: *Bemisia* 1995: Taxonomy, biology, damage, control and management. Intercept, Ltd., Publishers, U.K. 1996.

DUFFUS, J.E., H.-Y. LIU, and G.C. WISLER. Tomato infectious chlorosis virus-- A new clostero-like virus transmitted by *Trialeurodes vaporariorum*. Eur. J. Pl. Path. 102:219-226. 1996.





# DEVELOPMENT OF SUGARBEET BREEDING LINES AND GERMPLASM

R.T. LEWELLEN

**C913-70** - This line as well as CR09, CR10, and C51 were proposed for release in 1996 and fully described in the 1995 Sugarbeet Research Report, pages A18-A23. More abbreviated descriptions will be given in this report. These lines were officially released 10 October 1996. C913-70 (PI593691) is a marrowly based, self-fertile ( $S^f$ ), multigerm line. It has green hypocotyls ( $rr$ ) and segregates for genetic male sterility ( $aa$ ). It is the third bulked increase from an  $S_1$  progeny line. The second and third increases were from mother roots mass selected for resistance to rhizomania, caused by BNYVV. The  $S_1$  line was produced from one individually bagged mother root selected for resistance to rhizomania from population-913. Population-913 is a multigerm, self-fertile, genetic male-sterile facilitated random-mated population similar to C918 (PI 578079) that was undergoing population improvement. The  $S_1$  line was selected for further testing based on performance and nonbolting in an  $S_1$  progeny test. Experimental hybrids were produced in conjunction with subsequent seed increases. The line and experimental hybrids were evaluated in replicated field trials at Salinas, Davis, and Brawley, CA. On the basis of these tests, C913-70 was selected from a set of sister lines as having the best combination of yield and disease resistance. C918-70 has been tested as breeding lines 6913-70, 5913-70, 3913-70, and 1913-70.

**CR09 and CR10** - These are multigerm lines with moderate resistance to *Cercospora* leafspot, caused by *C.beticola*, and rhizomania, caused by beet necrotic yellow vein virus. Resistance to rhizomania is conditioned by the  $Rz$  allele. These line segregate for hypocotyl color, genetic male sterility, and self compatibility. Based upon greenhouse selfing, about half of the plants are self-fertile ( $S^f$ ) and half self-sterile ( $S^fS^s$ ). Selection for CR has caused a shift toward green hypocotyl color. *Cercospora* resistance (CR) was derived from Italian sugarbeet accessions obtained from the breeding programs of Enrico Biancardi at Rovigo. After evaluation and increase, two of the accessions were given the Salinas breeding line designations of R05 and R06. These CR sources were crossed to genetic male sterile plants from two Salinas breeding populations: R05 to population-747 and R06 to population-911. Following selection for resistance to rhizomania, selected plants from each line were pair crossed to rhizomania resistant plants from population-915. Population-915 is similar to previously released C918 (PI 578079). Each pair cross was maintained separately. These pair-crossed families were grown in a progeny test under *Cercospora* and rhizomania conditions in 1993. The most dually resistant plants within the most resistant families were selected, pooled within sets, and increased. Breeding line R409 traces to R05 and R410 to R06. R409 and R410 were mass selected for combined CR and resistance to rhizomania in 1995 and increased to produce C409 (PI 593692) (breeding line R609) and CR10 (PI 593693) (R610).

**C51** - C51 (PI 593694) is a self-sterile, multigerm, germplasm line that theoretically is 50% sugarbeet and 50% *Beta vulgaris* spp. *maritima*. The wild beet germplasm was derived from a collection of about 60 accessions. C51 is a version of C50 (PI 564243) that has been improved for sugarbeet traits and disease resistance. From C50 [=  $F_3$ (sugarbeet line Y54 x *B. vulgaris* spp. *maritima*)], improved subpopulations were created by four to six cycles of recurrent phenotypic selection for various combinations of productivity and

host-plant resistances. Selections have been made for biennialism, root and crown conformation, sucrose concentration, and root yield. Concurrently, selection was made for resistance to rhizomania, caused by beet necrotic yellow vein virus (BNYVV), and/or virus yellows (VY), caused by beet yellows and beet western yellows viruses. In 1995, mother roots selected for sucrose concentration and yield under severe rhizomania conditions from eight of these subpopulations were recombined to form C51. The component lines of C51 have been tested as versions of breeding line R22, e.g., R422Y3 and R422R5. C51 is being released and evaluated as breeding line R522. Subpopulation components of C51 (R22R lines) that had been selected for resistance to rhizomania have performed very well under severe rhizomania conditions. In tests at Salinas and Brawley, CA, they often have had higher sugar yield than commercially available rhizomania resistant hybrids. At Brawley under rhizomania conditions, these lines have shown the best known resistance to high temperature root rots and plant death. There is evidence that a factor or factors in C51 conditions a higher level of resistance to rhizomania (BNYVV) than that conditioned by Rz, the Holly gene. Experimental hybrids show that this factor is expressed in a dominant manner.

## **C76-89-5 and C913-70, TWO ADVANCED SUGARBEET BREEDING LINES**

- Since 1983 when rhizomania was discovered in California, breeders have been challenged to combine resistance to rhizomania with other disease resistance, nonbolting tendency, and components for sugar yield. In the USDA-ARS research and germplasm development program at Salinas, populations and breeding lines such as C78, C80, and C82 have been developed and officially released (Table 1) that should be useful to the industry as sources from which to extract useful parental lines for the production of multiple disease resistant hybrids.

TABLE 1. EXAMPLES OF SUGARBEET LINES  
OFFICIALLY RELEASED, 1994-1996

<u>Line</u>	<u>Description</u>
C78	Rz, MM, S <sup>s</sup> S <sup>s</sup> , breeding line (C46)
C80	Rz, MM, S <sup>s</sup> S <sup>s</sup> , breeding line (C54)
C82	Rz, MM, S <sup>s</sup> S <sup>s</sup> , breeding line (C31)
C76-89-5	Rz, MM, S <sup>s</sup> S <sup>s</sup> , line from full-sib progeny
C913-70	Rz,MM,S <sup>f</sup> ,line from S <sub>1</sub> progeny
CR09	Combined Rz & Cercospora resist.
CR10	Combined Rz & Cercospora resist.
C608	Combined Rz & cyst nematode resist.
C609	Combined Rz & cyst nematode resist.
C79-#	Sources of rhizomania resist. in C37
C890-#	Sources of rhizomania resist. in C790 monogerm background
C51	Enhanced sugarbeet x <i>B.maritima</i> (R22)

As part of this sugarbeet improvement research program, it is useful to produce various types of progeny families for evaluating and selecting superior genotypes. The very best of these progeny families is maintained and advanced individually, and may approach parental

line quality. Following further evaluation as lines per se and in experimental hybrids, a few are released to the industry. Two examples of these types of near-parental lines are C76-89-5 and C913-70 (Table 2). These lines may themselves be directly usable but more importantly they demonstrate the potential usefulness of the more broadly based improved germplasm lines from which they were selected as sources of combined disease resistance and improved productivity.

TABLE 2. RELEASED ADVANCED PROGENY LINES

<u>Line</u>	<u>Date</u>	<u>Description</u>
C76-89-5	1995	MM,S <sup>s</sup> S <sup>s</sup> ,Rz,NB,ER,VYR Advanced from 1 full-sib family from C31-89 x C31Rz
C913-70	1996	MM,S <sup>f</sup> ,A:aa,Rz,NB,ER,VYR, CTR Advanced from 1 S <sub>1</sub> (selfed) family from population-913

The evaluation of C76-89-5 and C913-70 was in tests conducted only on Salinas and Brawley experiment stations (Table 3,4). Ultimately, more reliable results will be required by the industry from tests over a wider range of geographical, environmental, seasonal, planting, and harvest date conditions. In addition, if these lines still show parental line potential, they will need to be fine tuned. However, C913-70 and C76-89-5 demonstrate that continued improvement in sugarbeet productivity (Table 5), stability due to disease resistance (Tables 6,7,8,9) and reduced reliance upon pesticides are realizable in the near future.

TABLE 3. LINE PERFORMANCE OF  
C76-89-5 & C913-70

<u>Line</u>	<u>Erwinia</u> <u>DI</u>	<u>PM</u> <u>Score</u>	<u>Bolting</u> <u>%</u>
US H11	10	5.3	
C40(susc.ck.)	97	5.1	
C76-89-5	11	4.1	3
C913-70	1	3.6	0
SP22-0(susc.ck.)			64
C37			1

Salinas, 196,1396. DI = disease index =  
% rot/root. PM = powdery mildew scored  
0 to 9 (susceptible).

TABLE 4. HYBRID PERFORMANCE OF  
C76-89-5 & C913-70

Hybrid	Erwinia DI	PM Score	Bolting %
US H11	7	5.3	1
C40 (susc.ck)	96	5.4	
CMS x C76-89-5	7	4.2	0
CMS x C913-70	11	4.2	0
Rizor	4	5.4	12
Rival	10	5.2	49
4006R		4.6	0
SS-NB3			0

Salinas, 296, 1296. DI = disease index =  
% rot/root. PM = powdery mildew scored  
0 to 9 (susceptible).

TABLE 5. HYBRID PERFORMANCE OF  
C76-89-5 & C913-70  
WITHOUT SEVERE DISEASE

Hybrid	Sugar Yield (lbs/a)	% Sugar
CMS x C76-89-5	12100	15.1
CMS x C913-70	11600	14.2
US H11	8900	13.3
4454 (BTS)	11000	14.4
Rizor (SES)	11400	16.0
Rival (Holly)	10800	15.1
6770 (KWS)	11300	15.6
-----		
LSD(.05)	800	0.4

Salinas, 296, 1296. DI = disease index =

TABLE 6. HYBRID PERFORMANCE OF  
C76-89-5 & C913-70  
VIRUS BY INOCULATION

Hybrid	Sugar Yield (lbs/a)	% Sugar	VY Score
CMS x C76-89-5	9400	14.4	3.7
CMS x C913-70	9300	13.4	3.8
4454 (BTS)	8200	13.7	5.4
Rival (Holly)	6000	13.6	6.0
6770 (KWS)	6000	14.2	6.0
-----			
LSD(.05)	810	0.4	0.3

Salinas, 1696. Inoculated BYV-BWYV-CRV.  
VY scored 0 to 9 (susceptible).

TABLE 7. HYBRID PERFORMANCE OF  
C76-89-5 & C913-70  
REACTION TO VIRUS YELLOWS

Hybrid	Sugar Yield(lbs/a)		% Loss	VY Score
	Non-inoc	Inoc		
CMS x C76-89-5	12100	9400	22	3.7
CMS x C913-70	11600	9300	20	3.8
4454 (BTS)	11000	8200	26	5.7
Rival (Holly)	10800	6000	43	6.0
6770 (KWS)	11300	6000	46	6.0
-----				
LSD(.05)	800	810		0.3

Salinas, 1696 & 2196. Inoc. BYV-BWYV-CRV.  
VY scored 0 to 9 (susceptible).

TABLE 8. HYBRID PERFORMANCE OF  
C76-89-5 & C913-70  
RHIZOMANIA

Hybrid	Sugar Yield(lbs/a)		% Sugar	
	Moderate	Severe	Mod	Severe
CMS x C76-89-5	9100	--	15.2	---
CMS x C913-70	9900	5500	14.7	12.7
US H11 (susc.ck)	5200	1400	12.6	8.5
Rizor (SES)	9300	4600	15.9	14.4
Rival (Holly)	8600	4300	14.8	13.1
4006R (BTS)	8900	4600	15.6	13.9
-----				
LSD(.05)	800	700	0.4	0.5

Salinas, 4396 & 6296. CMS = C790-15CMS.

TABLE 9. HYBRID PERFORMANCE OF  
C76-89-5 & C913-70  
IMPERIAL VALLEY

Hybrid	Sugar Yield (lbs/a)	% Sugar
CMS x C76-89-5	10900	15.5
CMS x C913-70	10500	14.8
US H11	7800	13.7
SS-IV3	9600	14.8
-----		
LSD(.05)	900	0.7

Brawley, B296. CMS = C790-15CMS.

**RESISTANCE TO RHIZOMANIA FROM LINE R22 (C50, C51)** - On the opposite end of the spectrum of released germplasm are lines such as C50 and C51 (Salinas breeding line R22 = R522). These lines involve prebreeding and enhancement of wild beet (*Beta vulgaris* spp. *maritima*) germplasm introgressed into sugarbeet. Of particular interest from R22 is high resistance to rhizomania. This resistance appears to be stronger than that conditioned by the *Rz* factor (Table 1). This R22 resistance is being backcrossed into sugarbeet breeding lines. In tests at Salinas under increasing severities of rhizomania, whereas the relative sugar yield of US H11 compared to Y562 (a broadly based breeding lines with the *Rz* factor) decreases, R522 increases (Table 1). Backcross lines such as Y564 (25 % *Bvm*) and Y565 (6% *Bvm*) appear to have retained the factor(s) for this higher resistance. One of the emphases of the breeding program will be to put this resistance into commercially acceptable breeding lines.

When R22 and backcross lines are evaluated under rhizomania in Imperial Valley, the factors for resistance to rhizomania and high temperature root rots (plant death) also are evident in terms of relative sugar yield (Table 2) and plant survival. It appears likely that the high temperature root rot resistance is an expression of this higher level of resistance to rhizomania allowing the plants to persist under the combined effects of rhizomania and high temperature stress.

TABLE 1. PERFORMANCE UNDER RHIZOMANIA  
OF SUGARBEET LINES WITH WILD BEET  
GERMPLASM FROM R22

Line	Gener- ation	% WB	Relative Sugar Yield		
			w/o	Moder	Severe
US H11	Susc.ck	0	95	63	36
Y562	Rz	0	100	100	100
R522	C51	50	93	109	118
Y564	BC <sub>1</sub> F <sub>2</sub>	25	97	117	128
Y565	BC <sub>3</sub> F <sub>2</sub>	6	100	109	128
-----					
LSD(.05)		9	11	16	

Salinas, 1996.

TABLE 2. PERFORMANCE UNDER RHIZOMANIA  
OF SUGARBEET LINES WITH WILD BEET  
GERMPLASM FROM R22

Line	Gener- ation	% WB	Relative Sugar Yield			
			w/o	Moder	Severe	Brawley
US H11	Susc.ck	0	95	63	36	64
Y562	Rz	0	100	100	100	100
R522	C51	50	93	109	118	125
Y564	BC <sub>1</sub> F <sub>2</sub>	25	97	117	128	118
Y565	BC <sub>3</sub> F <sub>2</sub>	6	100	109	128	---
-----						
LSD(.05)		9	11	16	21	

Salinas & Brawley, 1996.

# EFFECTS OF SOLARIZATION, FUMIGATION, DATES OF HARVEST, VARIETIES, AND CROP HISTORY ON RHIZOMANIA AND SOIL-BORNE PESTS IN THE IMPERIAL VALLEY

- Test B496 is the final test of a series of four trials run over 3 years by R. Lewellen, USDA-ARS, and Dr. Anne Wrona, formerly of U.C. Cooperative Extension on the Irrigated Desert Research Station, Brawley, CA. These trials were run to determine the efficacy of solarization and resistant varieties in comparison to nontreated and methyl bromide controls to alleviate the effects of rhizomania on sugarbeet.

Tests B695 and B496 were grown in an area known to be infested with rhizomania. In the spring of 1993, soil from an adjacent area was broadcast over this site and a 3 month inoculation sugarbeet crop grown and disced under. Variety trials were grown in 1993-94. In the summer of 1994, four soil treatments were established in a four replication, RCB design (no treatment, solarization, vapam and tarped methyl bromide + chloropicrin) (Table 1). In 1994-95 for test B695, four varieties and two harvest date treatments were superimposed over these soil treatments. In summary, the 1994-95 test (test B695) suggested that under these conditions, solarization gave the best protection against rhizomania (and other attendant soil-borne problems) followed in order by methyl bromide and then vapam as compared to the nontreated control. Under the solarization treatment in which there appeared to be essentially no rhizomania, the rhizomania susceptible commercial hybrid had higher yield than the rhizomania resistant entries. Under the nontreated check, USDA experimental hybrid with rhizomania resistance from wild beet (*Beta maritima*) had the highest yield. Because of the expense of solarization and methyl bromide, it was of interest to see if the benefits of solarization could be amortized over more than one year. In 1995-96 crop year, three varieties and two harvest dates were again superimposed over the original soil treatments (Table 1). The varieties were susceptible check HH41, moderately rhizomania resistant 4006R from Betaseed, and 5921H52 [(C762-17CMS x C790-15) x (C918aa x R422R5)], a USDA experimental hybrid. This hybrid is 87.5% sugarbeet (*B.vulgaris*) and 12.5% *B.maritima*. Resistance to rhizomania was derived from C918 for Rz Holly resistance and the *B.maritima* component, R22 (= C51). R22 lines and hybrids have shown previously the highest level of resistance to rhizomania and high temperature root rots in tests in the Imperial Valley.

TABLE 1. EFFECTS OF SOIL, VARIETY, HARVEST DATE & CROP HISTORY TREATMENTS ON SUGARBEET PERFORMANCE UNDER RHIZOMANIA

<u>SOIL TREATMENTS</u>		
Control (nontreated, rhizomania infested)		
Solarization (6 weeks, Aug-Sept, 1994)		
Vapam		
MethylBromide/Chloropicrin (75:25 @ 350 lbs/a)		
<u>VARIETIES</u>		
1995	1996	
HH 41	HH 41	Susceptible check
Rhizoguard	4006R	Rz,mod.resist. hybrid
4915H93		Rz,mod.resist. hybrid
R422R4H52	5921H52	Exp.hybrid R22 resist
<u>HARVEST DATES</u>		
20 May 1995	22 May 1996	
6July 1995	2July 1996	
-----		
<u>CROP HISTORY</u>		
1995	1st crop after soil trtmts (B695)	
1996	2nd crop, plant back (B496)	
<hr/>		
Tests B695 & B496, Brawley, CA.		



The results of test B496 in 1995-96 show that there was a carry-over benefit to solarization and the soil fumigation treatments in comparison to the nontreated check (Table 2). Solarization remained significantly better at controlling rhizomania than the soil fumigation treatments (Table 3). Rhizomania susceptible commercial hybrid HH41 had significantly lower sugar yield than 4006R. Experimental rhizomania resistant hybrid 5921H52 was significantly higher yielding than moderately resistant, commercial hybrid 4006R (Table 4). As observed in the past and contrary to sugarbeet yields under nondiseased conditions, the late (July) harvest was lower yielding than the earlier (May) harvest (Table 5). This difference can largely be explained by the loss of plants due to root rot caused by the combination of rhizomania and high temperature conditions.

TABLE 2. CARRY-OVER EFFECTS OF SOLARIZATION AND FUMIGATION ON SUGARBEET PERFORMANCE

<u>SOIL TRTMT</u>	<u>Sugar lbs/a</u>	<u>Roots t/a</u>	<u>Sucrose %</u>	<u>Rot %</u>
Control	3300	13	12.6	24
Solarization	8300	28	14.8	8
Vapam	5000	19	12.9	21
MB/Chl	5900	21	13.9	12
LSD(.05)	990	3	0.6	5

Test B496, Brawley, CA. Planted 9-13-95.

TABLE 3. EFFECTS OF SOLARIZATION AND FUMIGATION ON SUGARBEET PERFORMANCE UNDER RHIZOMANIA

<u>SOIL TRTMT</u>	<u>1st crop (1995)</u>		<u>2nd crop (1996)</u>	
	<u>Sugar lbs/a</u>	<u>% Rot</u>	<u>Sugar lbs/a</u>	<u>% Rot</u>
Control	5500	13	3300	24
Solarization	9200	1	8300	8
Vapam	7000	5	5000	21
MB/Chl	8300	0	5900	12
LSD(.05)	600	5	990	5

Tests B695 & B496, Brawley, CA.

TABLE 4. EFFECTS OF VARIETIES ON SUGARBEET PERFORMANCE UNDER RHIZOMANIA

<u>1st Crop (1995)</u>			<u>2nd Crop (1996)</u>		
<u>VARIETY</u>	<u>Sugar lbs/a</u>	<u>% Rot</u>	<u>VARIETY</u>	<u>Sugar lbs/a</u>	<u>% Rot</u>
HH 41	7200	8	HH 41	4100	24
Rhizoguard	6900	2	4006R	5400	14
4915H93	7100	6			
R22H52	8800	3	R22H52	7400	11
LSD(.05)	600	5		900	5

Tests B695 & B496, Brawley, CA.

R22H52 = R422R4H52 in 1995 & 5921H52 in 1996.

TABLE 5. EFFECTS OF HARVEST DATES  
ON SUGARBEET PERFORMANCE UNDER RHIZOMANIA

1st Crop (1995)			2nd Crop (1996)		
HARV DATE	Sugar lbs/a	% Rot	HARV DATE	Sugar lbs/a	% Rot
20 May 1995	7400	3	22 May 1996	6400	5
6 July 1995	7600	7	2 July 1996	4800	28

Tests B695 & B496, Brawley, CA.

Of the possible 16 interaction means in 1995 and 12 interaction means in 1996 for soil treatments x varieties over harvest dates, only 4 are shown in Table 6. These results are what would be expected. Under both crop histories, the lowest yield was for control x HH41. R22H52 had significantly higher yield than susceptible HH41 under the nontreated control conditions. Under the solarization treatment that apparently gave high control of rhizomania, the susceptible hybrid HH41 had higher yield than R22H52 in the first crop year but not the second. This suggested that sufficient rhizomania had reinfested the solarization treatments to decrease the yield of HH41 relative to R22H52. Whereas the combined benefits of solarization and resistance appeared to maintain the yield potential to the second crop, reintroduction of rhizomania reduced the yield of susceptible HH41.

TABLE 6. EXAMPLES OF 2-WAY INTERACTIONS OF  
SUGARBEET PERFORMANCE UNDER RHIZOMANIA

SOIL TRTMT x VAR	1st crop		2nd crop	
	Sugar lbs/a	% Rot	Sugar lbs/a	% Rot
Control x HH 41	4300	21	1700	38
Control x R22H52	7500	7	5000	16
Solarization x HH 41	9800	0	7500	10
Solarization x R22H52	9400	1	9800	6
LSD(.05)	1200	10	1700	10

Tests B695 & B496, Brawley, CA.

R22H52 = R422R4H52 in 1995 & 5921H52 in 1996.

These were relatively small plot areas. Farming and cultural practices and the movement of soil from nontreated adjacent areas may have been the source of renewed rhizomania infestation. If this were so, then solarization of larger areas or whole fields would reduce this source of inoculum and even less reinfestation would likely have occurred. The variety arrangement of the plant-back trial did not match the variety order or orientation of the first crop trial. Thus the combined solarization x resistant variety treatment did not occur back-to-back. It may be that the combined effects of solarization and host-plant resistance would have lead to even less reinfestation than was suggested by this study.

Four of the possible eight interaction means for soil treatment x harvest date are shown in Table 7. As has been often shown in the past under rhizomania conditions, there is a loss of yield and increased root rot (plant death) as the season progresses and becomes hotter. In 1995 when rhizomania was controlled with solarization, the longer season resulted in a significantly increased yield. For the second crop, the effects of solarization appear to have been lessened and the highest yield is for the May harvest.

TABLE 7. EXAMPLES OF 2-WAY INTERACTIONS OF SUGARBEET PERFORMANCE UNDER RHIZOMANIA

<u>SOIL x HARV DATE</u>	<u>1st crop</u>		<u>2nd crop</u>	
	<u>Sugar</u> <u>lbs/a</u>	<u>%</u> <u>Rot</u>	<u>Sugar</u> <u>lbs/a</u>	<u>%</u> <u>Rot</u>
Control x May	6000	6	4000	9
Control x July	5000	20	2500	40
Solarization x May	8800	2	8900	0
Solarization x July	9600	0	7700	15
LSD(.05)	500	6	900	9

Tests B695 & B496, Brawley, CA.

Four variety x harvest date interaction means for each year are shown in Table 8. The frequency of rotted roots greatly increased in the second crop.

TABLE 8. EXAMPLES OF 2-WAY INTERACTIONS OF SUGARBEET PERFORMANCE UNDER RHIZOMANIA

<u>VARIETY x HARV DATE</u>	<u>1st crop</u>		<u>2nd crop</u>	
	<u>Sugar</u> <u>lbs/a</u>	<u>%</u> <u>Rot</u>	<u>Sugar</u> <u>lbs/a</u>	<u>%</u> <u>Rot</u>
HH 41 x May	7600	1	5100	10
HH 41 x July	6800	14	3000	37
R22H52 x May	8300	4	7800	0
R22H52 x July	9300	2	6900	22
LSD(.05)	500	6	800	8

Tests B695 & B496, Brawley, CA.

R22H52 = R422R4H52 in 1995 & 5921H52 in 1996.

Of the possible 32 three-way interaction means in 1995 and 24 in 1996, only the extremes are shown in Table 9. As might be expected, the very lowest yield is for no soil treatment with a susceptible variety at the last harvest date. With increased severity of rhizomania for the second crop, this combination gave less than 1000 lbs sugar per acre and greater than 57% dead plants. In 1995, the highest yield was for either methyl bromide or solarization treatments with a resistant

variety at the July harvest date. In 1996, the highest yield was for the R22H52 hybrid under solarization.

TABLE 9. EXAMPLES OF 3-WAY INTERACTIONS OF  
SUGARBEET PERFORMANCE UNDER RHIZOMANIA

<u>SOIL x VAR x HARV DATE</u>	<u>1st crop</u>		<u>2nd crop</u>	
	<u>Sugar</u> <u>lbs/a</u>	<u>%</u> <u>Rot</u>	<u>Sugar</u> <u>lbs/a</u>	<u>%</u> <u>Rot</u>
Control x HH41 x July	3000	40	900	57
MB/Ch1 x R22H52 x July	10000	2	7700	17
Solar x R22H52 x May	8500	0	10000	0
Solar x R22H52 x July	10300	0	9600	12
LSD(.05)	1000	11	1600	16

Tests B695 & B496, Brawley, CA.

R22H52 = R422R4H52 in 1995 & 5921H52 in 1996.

# INDEX OF VARIETY TRIALS, SALINAS, CA, 1995-96 AT THE U.S. AGRICULTURAL RESEARCH STATION

Tests were located in five fields and established at five planting dates. All tests were under rhizomania infested soil conditions, except those in Block 5. Nortron, Pyramin, and Betamix were applied for weed control. Bayleton was used to control powdery mildew except in powdery mildew evaluation trials. Lorsban-4E was applied to some tests for insect control. The specific planting and harvest dates as well as plot size and design are shown on each test summary.

Tests are listed in the main table of contents for Salinas by types of material and evaluation. As an aid to find test summaries, they are listed below by ascending test number and cross referenced to the page number. Tests shown as N/A for page number were not included in this Report.

<u>TEST NO.</u>	<u>NO. ENTRIES</u>	<u>TEST DESCRIPTION</u>	<u>PAGE NO.</u>
<u>BOLTING EVALUATION TESTS, BLOCK 2N, PLANTED NOVEMBER, 1995</u>			
196	160	Bolting Evaluation of Lines	
296	120	Bolting Evaluation of Hybrids	
396	40	Bolting Evaluation of Accessions	N/A
496	30	Evaluation/Selection of Nonbolting	
<u>ERWINIA ROOT ROT/POWDERY MILDEW EVALUATION, BLOCK 5, APRIL, 1996</u>			
1196	60	Coded Powdery Mildew	N/A
1296	80	ERR/PM Evaluation of Hybrids	
1396	160	ERR/PM Evaluation of Lines	
<u>VIRUS YELLOWS (BYV/BWYV/CRV) EVALUATION, BLOCK 5, APRIL 1996</u>			
1496	12	Populations with GP from <i>B.maritima</i>	
1596	24	VY Evaluation of Multigerm Lines	
1696	24	VY Evaluation of Hybrids	
<u>NON-DISEASED YIELD TESTS, BLOCK 5, APRIL 1996</u>			
1796	12	Populations with GP from <i>B.maritima</i>	
1896	48	Performance of Germplasm Lines	
1996	24	Near-Isolines of C37 (C79-#s)	
2096	24	Performance of Monogerm Lines	
2196	48	Performance of Experimental Hybrids	
2296	24	Performance of C79-# Hybrids	
2396	24	Performance of Population Hybrids	
<u>SEVERE RHIZOMANIA, BLOCK 2S, MAY 1996</u>			
3196	31	Selection For Resistance	N/A
3296	16	Evaluation of Cyst Nematode Resistance	N/A
3396	4	Selection for Resistance	N/A
3496	32	Evaluation of Progeny Lines	N/A
3596-1	64	Evaluation of Lines	
3696	16	Populations with GP from <i>B.maritima</i>	
3796-1	32	WS/BTS/USDA Hybrid Evaluation	
3896	24	Transgenic Resistance to BNYVV	N/A
3996	32	Near-Isolines of C37 (C79-#s)	
4096-1	64	CBGA Coded	
4196	32	Evaluation of Population Hybrids	

<u>TEST NO.</u>	<u>NO. ENTRIES</u>	<u>TEST DESCRIPTION</u>	<u>PAGE NO.</u>
<u>MODERATE RHIZOMANIA, BLOCK 2S, MAY 1996</u>			
4296	16	Evaluation of C79-# Hybrids	
3596-2	64	Evaluation of Lines	
3796-2	32	ES/BTS/USDA Hybrid Evaluation	
4096-2	64	CBGA Coded	
4396	32	Evaluation of Hybrids	
4496	16	Evaluation of Monogerm Lines	
4596	16	Evalaution of Monogerm Population	
<u>POWDERY MILDEW EVALUATION, FIELD C, JUNE 1996</u>			
5196	12	Evaluation of Lines	N/A
<u>CERCOSPORA/RHIZOMANIA EVALUAITON/SELECTION, FIELD C, JUNE 1996</u>			
5396	72	CR-RZM Progeny Eval./Sel.	N/A
5496	12	CR-RZM Evalaution of Lines	
<u>RHIZOMANIA EVALUATION, FIELD C, JUNE 1996</u>			
5296	32	PI Evaluation of <i>B.maritima</i>	
5596	24	Evaluation of Early vs. Late	N/A
5696	60	Progeny Evaluation	N/A
5796	12	Evaluation of Monogerm Lines	
5896	16	Populations with GP from <i>B.maritima</i>	
5996	16	Evaluation of Multigerm Lines	
6096	32	Near-Isolines of C37 (C79-#s)	
6196	16	Evaluation of C79-# Hybrids	
6296	16	Evaluation of Hybrids	
<u>RHIZOMANIA RESISTANCE SELECTION, FIELD A, AUGUST 1996</u>			
7196	175	Selection for Rhizomania Resistance	N/A

# TEST 1896. PERFORMANCE OF GERMPLASM LINES, SALINAS, CA., 1996

48 varieties x 8 reps, RCB (equalized); 3 subtests: 16V x 8R, RCB (e) Planted: April 15, 1996  
1-row plots, 21 ft. long Harvested: October 2, 1996

Variety	Description	Acre Yield		Beets/ 100'	RJAP	Bolting	Root
		Sugar	Beets				
		Lbs	Tons	No.	%	%	%
<u>1896-1: Multigerm, O.P., breeding lines</u>							
6770	high %S check, 2-8-96, KWS	11630	36.25	143	82.9	0.0	0.4
4454	Comm.check, 4454.4002 (4-28-95)	12571	42.15	143	82.2	0.0	0.0
F86-31/6	Inc. C31/6, L86263	8539	29.36	122	80.7	0.0	0.0
R576	NB-ER-RZM R376, R376Y, (C31Rz)	10103	35.75	137	79.6	0.0	0.0
R581	RZM R481-43, R481-89, (C82)	11298	39.72	130	81.1	0.0	0.0
R576-89-18NB	NB-ER-RZM R376-89-18, (C76-89-18)	9598	32.17	117	80.8	0.0	0.0
R578%	RZM-%S R378(Sp)	12186	39.78	148	81.7	0.0	0.0
R578/2	NB-ER-RZM R378, R378Y (C78/2)	10313	34.50	137	80.8	0.0	0.0
R578(Sp)	RZM R478NB (C78)	10996	36.55	132	81.6	0.0	0.0
R580	NB-ER-RZM R380, R380Y	12372	41.45	138	81.2	0.0	0.0
R580NB	RZM R480NB (C80NB)	11506	39.05	145	80.5	0.0	0.0
R580%	RZM-%S R380(Sp)	11617	40.05	129	80.5	0.0	0.0
R580-#	RZM R480-# (C80-#)	11799	39.08	142	81.3	0.0	0.0
R580-45	RZM R480-45 (C80-45)	11313	36.74	136	81.2	0.0	0.0
Y562	RZM Y462R, F <sub>2</sub> (Y#rr(C) x R#(C))	10854	37.50	147	81.1	0.0	0.0
Y563	RZM Y463, F <sub>2</sub> (Y#R(C) x R#(C))	11736	39.34	140	81.4	0.0	0.0
Mean		11152.0	37.47	136.6	81.2	0.0	0.03
LSD (.05)		965.8	2.96	13.6	1.5	---	0.29
C.V. (%)		8.8	7.98	10.0	1.8	---	1132.70
F value		9.6**	10.25**	3.2**	2.0*	---	1.00NS

## TEST 1896. PERFORMANCE OF GERMPLASM LINES, SALINAS, CA., 1996.

48 varieties x 8 reps, RCB (equalized). ANOVA to compare means across sets of entries.

Mean	11214.2	37.99	14.76	140.2	80.7	0.1	0.06
LSD (.05)	1023.2	3.07	0.51	13.3	1.5	0.5	0.62
C.V. (%)	9.3	8.21	3.48	9.6	1.9	563.2	1014.40
F value	5.7**	6.22**	10.37**	3.0**	6.6**	6.5**	0.92NS

NOTE: See 1596 (virus yellows infected) and 3596-1, 3596-2, & 5996 (rhizomania).

TEST 1896. PERFORMANCE OF GERMLASM LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	RJAP %	Bolting %	Root Rot %
		Sugar	Beets				
		Lbs	Tons				
1896-2: Multigerm, O.P., breeding lines							
Rizor	Lot F291, 2-13-96 (SES)	12527	37.31	16.79	80.9	0.0	0.0
US H11	L113401, 11-16-94	10342	35.80	14.41	81.0	0.0	0.0
R570	NB-ER-RZM R370	11255	37.51	14.99	79.9	0.0	0.0
R539	NB-ER-RZM R137C7, (C39R)	11266	38.35	14.70	80.7	0.0	0.4
R547	NB-ER-RZM R147C7, (C47R)	10505	35.21	14.93	81.5	0.0	0.0
R581-43	NB-ER-RZM R381-43	10605	36.67	14.46	79.7	0.0	0.0
R576-89	NB-ER-RZM R376-89-#, R381-89	11025	37.65	14.65	81.9	0.0	0.0
Y564(Iso)	RZM 4205,P;..4208,P,F <sub>2</sub> (S'S' x R22Y)	10740	35.70	15.02	81.2	0.0	0.0
Y565	RZM 4280,P;4284,P,F <sub>2</sub> (R80,R84xR43)	11808	41.17	14.35	79.4	0.0	0.0
R540-1	RZM R440-1R, F <sub>2</sub> (C37 x R40(C))	10500	36.60	14.34	79.9	0.0	0.0
R540%(Iso)	RZM-%S 3201-3285	10733	36.46	14.70	79.5	0.0	0.0
R576-89-18H19	4918-#(C)aa x R476-89-18	12599	41.70	15.09	81.1	0.0	0.0
R581H18	RZM 4918aa x RZM R481-43,-89 (C82)	12329	42.72	14.43	80.7	0.0	0.0
R578H19	4918-#(C)aa x RZM R478NB (C78)	12286	40.76	15.06	81.8	0.0	0.0
R522(Sp)	RZM-%S R22(C), (C51)	10687	37.30	14.32	78.4	0.4	0.0
R526	RZM R426R, F <sub>2</sub> (C37 x UK B.m.)	9139	33.25	13.79	77.2	3.3	1.3
Mean		11146.6	37.76	14.75	80.3	0.2	0.1
LSD (.05)		1019.2	3.06	0.54	1.5	0.8	0.9
C.V. (%)		9.2	8.19	3.73	1.9	356.8	901.3
F value		6.8**	5.62**	11.08**	5.6**	7.9**	1.0NS

NOTE: 4918-#(C) = composite of S<sub>1</sub>'s from C918.



TEST 1896. PERFORMANCE OF GERMPASM LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	RJAP	Bolting	Root
		Sugar Lbs	Beets Tons				
1896-3: Multigerm, S', Aa populations							
Rival	HH103, L1031203, 8-29-95	11670	37.09	148	80.4	0.0	0.4
4006R	Betaseed, 2-8-96	11370	34.95	124	83.2	0.0	0.5
4915	RZM 3915aa x A	11796	41.02	137	80.6	0.0	0.0
5915	RZM 4911,4915,4916,4918aa x A	12459	42.30	140	80.8	0.0	0.0
5925	S <sub>1</sub> (C)aa x RZM 4915-#(C),4918-#(C),...	11461	39.70	134	79.9	0.5	0.0
4918	RZM 3918aa x A, C918	11417	39.05	135	80.7	0.0	0.0
5915%	RZM-%S 3915(Sp)(A,aa)	11892	39.95	150	81.2	0.0	0.0
5920	RZM 4287, F <sub>2</sub> (918 x R44)	10445	37.52	134	79.2	0.0	0.0
5921(Sp)	RZM R422R4H15,R4H17,Y3H15, (25% B.m.)	11850		14.57	139	79.7	0.4
0.0							
5922	RZM R440H18	10664	37.50	142	80.0	0.0	0.0
5923	4918aa x RZM R40(C)	11433	39.20	145	80.9	0.0	0.0
5924	RZM 4918aa x Y-#(C1 & 2), Y462, Y463	11844	39.35	147	81.6	0.0	0.0
5911-4(Iso)	NB-ER-RZM 3911-4,RZM-%S 3911-4MA	10884	37.92	129	80.2	0.0	0.0
5822m	4265-4279mmaa x A	10683	37.88	151	81.1	0.0	0.0
5913-70	RZM 3913-70 (C913-70)	10332	34.70	142	79.2	0.0	0.0
N525	NR-RZM N427,N428 (A,aa)	11306	41.20	142	80.1	0.0	0.0
Mean		11344.0	38.75	140.0	80.5	0.1	0.1
LSD (.05)		1113.9	3.36	13.1	1.7	0.4	0.5
C.V. (%)		9.9	8.76	9.5	2.1	814.8	828.8
F value		2.3*	3.17**	2.5**	2.7**	0.9NS	0.9NS

# TEST 1596. EVALUATION OF MULTIGERM GERMPLASM UNDER VIRUS YELLOWS CONDITIONS, SALINAS, CA., 1996

24 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: October 1, 1996  
BYV/BWV Inoc.: June 4, 1996\*

Variety	Description	Acre Yield		Beets/ 100'	RJAP %	Root %	Virus Yellows Mean
		Sugar Lbs.	Beets Tons				
268	Inc. 768 (US 75), Susc. check	4631	20.05	11.57	74.7	0.0	6.1
6770	Susc., high %S check (2-8-96), KWS	5868	20.85	14.06	79.8	0.0	5.9
4454	Comm. check, 4454.4002 (4-28-95)	7520	27.78	13.52	78.8	0.0	5.4
F86-31/6	Inc. C31/6 (L86263)	7038	25.49	13.80	79.1	0.0	3.5
R539	NB-ER-RZM R139C7, (C39R)	6306	24.30	12.99	78.8	0.5	4.2
R570	NB-ER-RZM R370	7550	27.36	13.78	78.7	0.0	4.4
R576	NB-ER-RZM R376, R376Y, (C31RZ)	6661	25.22	13.18	78.7	0.0	3.8
R576-89-18NB	NB-ER-RZM R376-89-18, (C76-89-18)	7659	27.32	14.04	79.0	0.0	3.6
R578/2	NB-ER-RZM R378, R378Y, (C78/2)	6513	23.64	13.77	77.8	0.0	4.1
R580	NB-ER-RZM R380, R380Y	6595	24.63	13.40	79.0	0.0	4.8
R581(Sp)	RZM R481-43, -89, (C82)	8048	30.57	13.20	78.9	0.0	4.0
Y562	RZM Y462R; Y#(C)rr x R#(C)R	6931	25.70	13.48	78.4	0.0	4.2
Y563	RZM Y463; Y#(C)R x R#(C)R	7323	26.55	13.76	78.8	0.0	4.3
Y564(Iso)	RZM 4205, P, ..., S's' x R322Y3	7686	27.80	13.83	78.3	0.0	3.9
Y565	RZM 4280, P, ..., R80, R84 x R43	7157	27.53	12.99	77.7	0.0	4.3
R522(Sp)	RZM-%S R22R & R22Y(C) (C51)	6689	27.00	12.37	73.9	0.8	4.6
Y540%(Iso)	RZM-%S 3201-3285; C79-#'s	7054	26.85	13.14	76.1	0.0	4.2
5911-4M	RZM 4911-4Maa x A, (C911-4)	7629	28.83	13.23	76.6	0.0	3.9
5915	RZM 4911, 4915, 4916, 4918aa x A	7359	28.02	13.10	77.0	0.0	4.4
5925	S <sub>1</sub> (MM, S', Aa, Rz)aa x S <sub>1</sub> (4915, 4918)A	7716	29.03	13.26	76.9	0.0	4.1
5924	RZM 4918aa x Y#(C1), (C2); Y462, Y463	8153	30.13	13.52	78.2	0.0	4.2
5920	RZM 4287; 3918aa x R44	7621	29.62	12.87	76.5	0.0	3.8
5921(Iso)	RZM R422R4H17, H15; Y3H15	7211	27.50	13.11	76.5	0.0	3.9
5923	4918aa x RZM R40(C)	7411	28.25	13.11	77.5	0.0	4.5
Mean		7096.9	26.67	13.30	77.73	0.1	4.3
LSD (.05)		805.8	2.84	0.38	1.12	0.4	0.4
C.V. (%)		11.5	10.82	2.87	1.51	773.1	8.8
F value		7.0**	6.54**	16.44**	12.55**	1.6*	23.2**

NOTE: See tests 1896 (nondiseased) and 3596-1, 3596-2, & 5996 (rhizomania.)

\* Inoculated with virus yellows complex that included BYV, BWV, and the more recently identified luteovirus identified in CA, TX, CO, and NE. Virus yellows scored 5 times on a scale of 0 to 9 where 0 = green and 9 = 100% yellowed canopy. A seedling tip rot diagnosed as being caused by Phytophthora caused differential seedling loss and sprangling.

# TEST 3596-1. RHIZOMANIA EVALUATION OF LINES (SEVERE), BLOCK 2S, SALINAS, CA., 1996

64 entries x 4 replications, RCB; 4 subtests, 16 entries x 4 reps, RCB      Planted: May 1, 1996  
 1-row plots, 20 ft. long      Harvested: October 17, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	Bolters %	Powdery		
		Sugar	Beets				Mildew	RJAP	
		Lbs	Tons				Score	%	
3596 (subset 1): MM,O.P. Lines, 16V x 8R, RCB									
US H11 Rizor	L113401, 11-16-94	4797	22.18	10.82	169	0.0	8.0	77.6	
	Lot F291, 2-13-96	9181	29.77	15.43	178	0.0	7.8	77.5	
	C39R NB-ER-RZM R139C7	8206	31.92	12.85	164	1.6	6.0	79.4	
	C47R NB-ER-RZM R147C7	7911	29.54	13.35	170	0.0	7.3	81.3	
U86-46/2 R578%	Inc. C46/2, 86342	5200	20.08	12.95	163	0.0	6.5	80.3	
	RZM-%S R378(Sp)	8802	31.41	14.02	171	0.0	6.5	81.2	
	C78/2 NB-ER-RZM R378,Y	7128	25.57	13.95	178	0.0	6.0	79.5	
	C78 RZM R478NB	8338	29.89	13.98	178	0.0	6.5	80.7	
Y954 R580NB	Inc. Y854	6277	23.82	13.18	149	0.0	6.3	80.8	
	NB-ER-RZM R380,Y	8252	30.82	13.38	179	0.0	6.5	80.7	
	C80NB RZM R480NB (C80NB)	7992	30.24	13.23	171	0.0	6.5	81.5	
	R580% RZM-%S R380(Sp)	8606	31.41	13.73	173	0.0	6.8	79.2	
R580-# R580-45	RZM R480-#	7956	29.42	13.55	165	0.0	7.0	79.6	
	RZM R480-45(Iso)	9128	32.34	14.10	174	0.0	6.3	78.4	
	R570 NB-ER-RZM R370	7177	26.74	13.43	175	0.0	6.8	79.9	
	Y562 RZM Y462R	7424	29.65	12.52	184	0.0	6.3	79.3	
Mean		7648.4	28.42	13.40	171.1	0.1	6.7	79.8	
LSD (.05)		1094.3	4.02	0.73	17.9	0.7	0.7	2.9	
C.V. (%)		10.1	9.93	3.85	7.3	462.9	7.2	2.5	
F value		11.2**	6.78**	13.77**	1.8NS	3.0**	5.7**	1.5NS	

## TEST 3596-1. RHIZOMANIA EVALUATION OF LINES (SEVERE), BLOCK 2S, SALINAS, CA., 1996

64 entries x 4 replications, RCB; 4 subtests, 16V x 4R, RCB. ANOVA to compare means across sets of entries.

Mean	7704.4	28.92	13.31	171.7	0.1	6.8	79.3
LSD (.05)	1198.9	4.28	0.80	18.8	0.6	0.8	2.9
C.V. (%)	11.2	10.60	4.30	7.9	678.9	8.6	2.6
F value	6.6**	5.60**	5.80**	2.8**	1.8**	5.0**	2.4**

NOTE: See Test 3596-2 for performance under less severe rhizomania conditions. See Tests 1896 (nondiseased), 1596 (virus yellows), and 5996 (rhizomania).

TEST 3596-1. RHIZOMANIA EVALUATION OF LINES (SEVERE), BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Powdery Mildew	
		Sugar	Beets			Sucrose	Score
		Lbs	Tons			%	No.
3596 (subset 2): MM,O.P. Lines, 16V x 8R, RCB							
Rival	HH103, L1031203, 8-29-95	9434	32.46	14.55	183	0.0	7.0
	L950840, 11-13-95	7367	28.72	12.85	173	0.0	7.3
	Inc. C31/6, 86263	5801	22.84	12.73	148	0.0	6.0
	RZM R384 (Inc. R176-43,-89)	8149	29.65	13.75	169	0.0	6.5
R581(sp)	RZM R481-43,-89 (C82)	8232	33.38	12.38	143	0.0	6.0
	NB-ER-RZM R381-43	7756	28.25	13.73	160	0.0	6.5
	NB-ER-RZM R376,Y	6863	26.50	12.98	165	0.0	7.3
	RZM R376-43-14 (C76-43-14)	7102	28.27	12.57	170	0.0	6.8
R576-43-15	RZM R476-43-15 (C76-43-15)	6710	24.52	13.80	164	0.0	6.3
	RZM-ER-RZM R376-89-5 (C76-89-5)	6745	23.00	14.68	186	0.0	6.3
	RZM R476-89-18 (C76-89-18)	7110	25.99	13.70	148	0.0	6.5
	Inc. C37, 86443	4982	20.07	12.48	165	0.0	8.8
R579	RZM R479(Iso), C79-1(Rz)	6208	24.90	12.48	155	0.0	7.3
	RZM R435CMS, C79-7(SES)	8130	29.42	13.82	174	0.0	7.5
	RZM R436, C79-8(R22)	7587	30.12	12.60	189	0.0	8.3
	RZM-%S 3201-3285 (C37xC79-#'s)	8502	31.41	13.52	183	0.0	7.5
Mean		7292.2	27.47	13.29	167.0	0.0	7.0
	LSD (.05)	1204.4	4.77	0.90	17.5	0.0	0.7
	C.V. (%)	11.6	12.20	4.73	7.4	0.0	7.2
	F value	6.8**	4.95**	5.70**	5.3**	0.0	9.8**

TEST 3596-1. RHIZOMANIA EVALUATION OF LINES (SEVERE), BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Powdery Mildew	
		Sugar Lbs	Beets Tons			Sucrose %	Score
3596 (subset 3): MM,O.P. Lines, 16V x 8R, RCB							
4006R	2-8-96, Betaseed	8379	29.62	151	0.0	7.5	80.9
R540-1	RZM R440-1, Inc.(C37xC79-#'s)	6695	26.39	186	0.0	8.0	78.7
R540(Sp)	RZM R40(C), Inc.(C37xC79-#'s)	7611	30.12	169	0.0	7.5	78.3
R526	RZM R426, F <sub>2</sub> (C37 x UK Bm)	5434	21.60	168	1.4	8.0	75.5
R522(Sp)	C51 RZM-%S R322R4,R4%,Y3	8094	31.29	180	1.4	7.8	75.7
Y522Y4	RZM-%S R322Y3,Y3%	8200	30.00	183	0.0	6.5	79.3
Y564(Iso) <sup>1</sup>	RZM 4205,4206,4207,4208	8257	30.59	161	0.0	7.3	78.5
Y565 <sup>1</sup>	RZM 4280,4284	8214	32.34	185	0.0	7.8	75.0
Y566 <sup>1</sup>	Y-#(C1)rr x RZM 4205,...,4208	6931	26.45	164	0.0	7.0	78.8
Y567 <sup>1</sup>	Y-#(C2)rr x RZM 4205,...,4208	6680	24.28	161	0.0	5.8	80.4
Y568 <sup>2</sup>	Y-#(C1)rr x RZM Y462,Y463R	6285	23.93	179	0.0	6.5	81.0
Y569 <sup>2</sup>	Y-#(C2)rr x RZM Y462,Y463R	7539	26.50	169	0.0	6.3	81.1
R522H18 <sup>3</sup>	4918aa x RZM R522 (C51)	9219	33.22	159	0.0	6.8	78.2
R578H18 <sup>3</sup>	4918aa x RZM R478NB (C78)	9128	33.62	169	0.0	5.8	80.6
R581H18 <sup>3</sup>	RZM 4918aa x RZM R481-43,-89	9572	35.61	178	0.0	6.5	79.7
R576-89-18H18 <sup>3</sup>	RZM 4918aa x R476-89-18	9336	34.21	184	0.0	6.0	79.5
Mean		7848.5	29.36	171.5	0.2	6.9	78.8
LSD (.05)		1114.7	3.92	20.0	1.2	1.0	3.4
C.V. (%)		10.0	9.37	8.2	471.1	9.9	3.0
F value		9.3**	8.87**	2.3*	1.4NS	5.2**	2.7*

<sup>1</sup> Rhizomania resistance from C51 (R22 = SB x Bm) being backcrossed into breeding lines from the virus yellows breeding program. Y-#(C) = composite of VY lines.

<sup>2</sup> Rhizomania resistance Rz being backcrossed into VY breeding program.

<sup>3</sup> Toward development of random-mated, S', A:aa populations with resistance to rhizomania. 4918 = C918.

TEST 3596-1. RHIZOMANIA EVALUATION OF LINES (SEVERE), BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Powdery Mildew		RJAP %
		Sugar	Beets			Sucrose	Score	
		Lbs	Tons			%	No.	
33596 (subset 4): MM,S',Aa Lines, 16V x 8R, RCB								
5915	RZM 4911,4915,4916,4918aa x S <sub>1</sub> (C)A	8660	32.92	173	0.0	13.18	6.8	80.3
5925	S <sub>1</sub> (C) (MM,Aa,Rz)aa x A	7865	30.00	165	0.0	13.10	6.8	79.0
9903	YR-ER-PMR 7903(A,aa)	6312	25.22	174	0.0	12.52	7.0	81.4
5911-4M	RZM 4911-4Maa x A, (C911-4)	8207	30.94	174	0.0	13.30	6.3	78.2
5913-70	RZM 3913-70 (C913-70)	8081	28.82	193	0.0	14.02	7.0	79.6
5911-4-7	T-O Sel. 4911-4-7mm	7814	28.37	191	0.0	13.77	5.8	78.3
5920 <sup>3</sup>	RZM 4287	8255	31.58	169	0.0	13.10	7.0	79.5
5921(sp) <sup>3</sup>	RZM R422Y3H15;R422R4H15,H17	8667	32.46	160	0.0	13.35	7.0	77.6
5921H18 <sup>3</sup>	4918aa x "	9037	34.32	185	0.0	13.18	6.5	79.0
5922 <sup>3</sup>	RZM R440H18	7770	29.30	185	0.0	13.23	7.0	79.7
5923 <sup>3</sup>	4918aa x RZM R40(C)	8203	30.82	184	0.0	13.30	7.8	77.2
5924 <sup>3</sup>	RZM 4918aa x Y#(C)	8827	32.46	183	0.0	13.55	6.3	81.6
N525	NR-RZM N427,N428	7916	32.47	174	0.0	12.18	6.5	78.2
RR410	CR-RZM R210-#(C)	7410	27.90	169	0.0	13.30	7.0	83.4
P402NR	NR P202	7085	27.44	185	0.0	12.90	7.0	81.0
R544R2	RZM R444	8346	31.99	176	0.0	13.05	6.8	79.0
Mean		8028.4	30.44	177.3	0.0	13.19	6.8	79.6
LSD (.05)		1239.6	4.17	19.1	0.0	0.80	0.9	2.9
C.V. (%)		10.8	9.62	7.6	0.0	4.25	9.4	2.6
F value		2.5**	2.76**	2.0*	0.0	2.40*	2.0*	2.6**

<sup>3</sup> See footnotes on previous page.

TEST 3596-2: RHIZOMANIA EVALUATION OF LINES, MILD RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1996

64 entries x 4 replications, RCB; 4 subtests, 16 entries x 4 reps., RCB  
 1-row plots, 20 ft. long  
 Planted: May 1, 1996  
 Harvested: October 9, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Powdery Mildew Score
		Sugar Lbs	Beets Tons				
3596 (subset 1): MM,O.P. Lines, 16V x 4R, RCB							
US H11 Rizor R539 R547	L113401, 11-16-94	4973	21.10	11.83	193	79.8	7.5
	Lot F291, 2-13-96	9575	30.66	15.63	180	78.8	6.8
	NB-ER-RZM R139C7	8782	32.59	13.48	164	79.2	5.8
	NB-ER-RZM R147C7	9498	32.41	14.63	179	80.4	6.3
U86-46/2 R578% R578/2 R578(Sp)	Inc. C46/2, 86342	6054	22.79	13.25	158	78.8	5.5
	RZM-%S R378(Sp)	9666	33.08	14.63	190	80.5	5.8
	NB-ER-RZM R378,Y	8857	30.87	14.32	193	78.7	5.5
	RZM R478NB	9112	31.78	14.32	186	80.4	5.8
Y954 R580 R580NB R580%	Inc. Y854	6711	25.14	13.35	174	80.0	5.3
	NB-ER-RZM R380,Y	9363	33.50	13.98	174	79.5	5.5
	RZM R480NB (C80NB)	9185	33.49	13.70	171	78.7	6.0
	RZM-%S R380(Sp)	8729	30.98	14.10	181	78.5	6.3
R580-# R580-45 R570 Y562	RZM R480-#	9425	32.34	14.57	194	79.5	6.3
	RZM R480-45(Iso)	10265	34.33	14.95	179	80.9	5.8
	NB-ER-RZM R370	8671	31.03	13.95	170	78.3	6.3
	RZM Y462R	8204	30.12	13.63	185	78.9	6.0
Mean		8566.8	30.39	14.02	179.3	79.4	6.0
LSD (.05)		1156.9	3.63	0.86	26.1	2.0	1.0
C.V. (%)		9.5	8.39	4.30	10.2	1.8	11.2
F value		12.5**	9.40**	8.15**	1.3NS	1.3NS	2.7**

TEST 3596-2: RHIZOMANIA EVALUATION OF LINES, MILD RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1996

64 entries x 4 replications, RCB. ANOVA to compare means across sets of entries.

Mean	8527.0	30.20	14.08	181.9	78.9	6.2
LSD (.05)	1154.8	3.50	0.78	28.4	2.0	0.8
C.V. (%)	9.7	8.31	3.99	11.2	1.8	9.1
F value	7.4**	7.13**	5.46**	1.5*	3.0**	3.9**

NOTE: See Test 3596-1 for performance under more severe rhizomania conditions.

TEST 3596-2: RHIZOMANIA EVALUATION OF LINES, MILD RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Powdery Mildew Score
		Sugar	Beets				
		Lbs	Tons				
3596 (subset 2): MM,O.P. Lines, 16V x 4R, RCB							
Rival	HH103, L1031203, 8-29-95	9411	30.98	15.20	185	79.7	7.3
	L950840, 11-13-95	9299	32.44	14.30	178	80.5	6.8
	Inc. C31/6, 86263	6506	22.78	14.25	161	79.6	5.8
	RZM R384 (Inc. R176-43,-89)	8960	30.66	14.60	176	79.0	6.0
R581(Sp)	RZM R481-43,-89, (C82)	9846	35.49	13.88	170	80.0	5.8
	NB-ER-RZM R381-43	8707	30.14	14.48	184	80.3	6.0
	NB-ER-RZM R376,Y	8005	29.72	13.48	181	79.5	6.3
	RZM R376-43-14 (C76-43-14)	8482	30.03	14.13	180	81.0	6.3
R576-43-15	RZM R476-43-15 (C76-43-15)	8711	29.97	14.52	156	80.1	6.0
	RZM-ER-RZM R376-89-5 (C76-89-5)	8228	27.20	15.13	191	77.5	6.8
	RZM R476-89-18 (C76-89-18)	8229	28.95	14.23	151	78.4	6.0
	Inc. C37, 86443	5460	21.15	12.90	173	77.7	7.5
R579	RZM R479(Iso), C79-1(Rz)	8439	31.08	13.55	188	77.5	6.3
	RZM R435CMS, C79-7(SES)	8682	29.72	14.57	174	80.0	6.8
	RZM R436, C79-8(R22)	7469	28.74	12.95	184	76.2	7.5
	RZM-8S 3201-3285 (C37xC79-#'s)	8042	28.67	14.00	208	77.2	7.5
Mean		8279.7	29.23	14.13	177.4	79.0	6.5
LSD (.05)		1165.2	3.63	0.69	31.4	1.7	0.7
C.V. (%)		9.9	8.72	3.46	12.4	1.5	7.7
F value		7.1**	7.06**	7.41**	1.6NS	5.3**	6.4**



TEST 3596-2: RHIZOMANIA EVALUATION OF LINES, MILD RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	RJAP %	Powdery Mildew Score
		Sugar Lbs	Beets Tons			
3596 (subset 3): MM,O.P. Lines, 16V x 4R, RCB						
4006R	2-8-96, Betaseed	9554	30.36	15.73	80.0	6.8
R540-1	RZM R440-1, Inc.(C37 x C79-#'s)	7180	26.46	13.55	78.1	7.3
R540(Sp)	RZM R40(C), Inc.(C37 x C79-#'s)	8005	29.51	13.55	77.1	7.0
R526	RZM R426R, F <sub>2</sub> (C37 x UK Bm)	5874	22.47	13.10	75.0	7.5
R522(Sp)	C51 RZM-8S R322R4,R4%,Y3	8370	32.34	12.95	76.0	6.0
Y522Y4	RZM-8S R322Y3,Y3%	8489	29.72	14.27	78.8	5.8
Y564(Iso) <sup>1</sup>	RZM 4205,4206,4207,4208	8499	29.72	14.25	78.2	6.0
Y565 <sup>1</sup>	RZM 4280,4284	8993	32.24	13.90	77.9	6.8
Y566 <sup>1</sup>	Y-#(C1)rr x RZM 4205,....,4208	7307	26.46	13.77	79.9	6.3
Y567 <sup>1</sup>	Y-#(C2)rr x RZM 4205,....,4208	8161	28.35	14.32	80.0	5.5
Y568 <sup>2</sup>	Y-#(C1)rr x RZM Y462,Y463R	7320	26.36	13.93	78.4	6.3
Y569 <sup>2</sup>	Y-#(C2)rr x RZM Y462,Y463R	8396	28.98	14.48	79.8	6.0
R522H18 <sup>3</sup>	4918aa x RZM R522(C51)	9779	34.76	14.07	78.1	6.3
R578H18 <sup>3</sup>	4918aa x RZM R478NB (C78)	9354	32.03	14.60	79.1	6.0
R581H18 <sup>3</sup>	RZM 4918aa x RZM R481-43,-89 (C82)	9208	32.34	14.20	79.5	5.8
R576-89-18H18 <sup>3</sup>	RZM 4918aa x R476-89-18 (C76-89-18)	8992	30.63	14.65	79.8	6.0
Mean		8342.6	29.54	14.08	78.5	6.3
LSD (.05)		1309.2	4.02	0.70	2.2	0.8
C.V. (%)		11.0	9.55	3.48	2.0	8.4
F value		5.0**	4.66**	7.26**	0.9NS	4.7**

<sup>1</sup> See Test 3596-1.

<sup>2</sup> See Test 3596-1.

<sup>3</sup> See Test 3596-1.

TEST 3596-2: RHIZOMANIA EVALUATION OF LINES, MILD RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
		Sugar	Beets				
		Lbs	Tons				
<u>3596 (subset 4): MM,S',Aa Lines, 16V x 4R, RCB</u>							
5915	RZM 4911,4915,4916,4918aa x S <sub>1</sub> (C)A	10169	34.23	14.85	188	79.8	6.0
5925	S <sub>1</sub> (C)(MM,Aa,Rz)aa x A	9720	34.23	14.18	168	78.6	6.3
9903	YR-ER-PMR 7903(A,aa)	7497	27.50	13.60	161	80.1	6.0
5911-4M	RZM 4911-4Maa x A, (C911-4)	9584	33.39	14.38	206	78.4	6.0
5913-70	RZM 3913-70 (C913-70)	8992	30.66	14.68	209	77.2	5.3
5911-4-7	T-O Sel. 4911-4-7mm	8068	27.62	14.63	199	78.4	6.3
5920 <sup>3</sup>	RZM 4287	9534	34.44	13.82	188	79.1	6.0
5921(sp) <sup>3</sup>	RZM R422Y3H15;R422R4H15,H17	9144	32.03	14.25	194	78.8	6.3
5921H18 <sup>3</sup>	4918aa x "	9802	34.97	14.00	188	77.7	5.8
5922 <sup>3</sup>	RZM R440H18	8439	30.31	13.90	188	77.8	6.0
5923 <sup>3</sup>	4918aa x RZM R40(C)	9400	32.44	14.47	190	79.9	6.8
5924 <sup>3</sup>	RZM 4918aa x Y#(C)	9360	33.08	14.15	191	79.4	6.0
N525	NR-RZM N427,N428	9307	34.17	13.63	171	78.4	6.3
R410	CR-RZM R210-#(C)	8323	30.87	13.48	179	79.6	6.0
P402NR	NR P202	7377	26.67	13.82	194	79.1	6.8
R544R2	RZM R444	7982	29.40	13.57	194	77.1	6.0
Mean		8918.7	31.63	14.09	187.8	78.7	6.1
LSD (.05)		1047.3	3.22	0.62	25.6	1.9	0.8
C.V. (%)		8.3	7.14	3.09	9.6	1.7	9.6
F value		5.4**	5.80**	3.88**	2.1*	2.0*	1.5NS

<sup>3</sup> See footnote on previous page.

TEST 5996. RHIZOMANIA EVALUATION OF BREEDING LINES, FIELD C, SALINAS, CA., 1996

16 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: June 3, 1996  
Harvested: November 27, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Bolting %
		Sugar Lbs	Beets Tons				
Rizor	F291, 2-13-96, SES	3916	13.94	14.04	171	75.6	0.0
US H11	L113401, 11-16-94	1843	9.67	9.35	180	71.4	0.0
R539	NB-ER-RZM R139C7, (C39R)	4475	18.73	11.95	148	75.0	3.2
R547	NB-ER-RZM R147C7, (C47R)	4091	15.70	13.01	164	77.5	0.0
U86-46/2	Inc. C46/2, 86342	2755	11.64	11.88	135	74.6	0.0
R578/2	NB-ER-RZM R378,Y (C78/2)	4009	15.45	12.96	168	76.8	0.0
R578(Sp)	RZM R478NB (C78)	4064	16.17	12.44	168	73.5	0.0
R580	NB-ER-RZM R380,Y	4373	17.49	12.48	168	76.5	0.0
R580NB	RZM R480NB (C80NB)	3771	15.33	12.27	156	75.3	0.0
R581(Sp)	RZM R481-43,-89 (C82)	4469	18.52	12.02	157	77.3	0.0
R576	NB-ER-RZM R376,Y (C31Rz)	3908	16.06	12.20	153	77.1	0.0
Y562	RZM Y462R	3510	14.63	12.00	156	74.7	0.0
R522(Sp)	RZM-%S R322R4, R4%, Y3 (C51)	4155	17.76	11.71	166	72.8	0.0
Y564	RZM 4205-4208	4494	17.88	12.59	153	73.9	0.0
R570	NB-ER-RZM R370	4076	16.50	12.40	155	75.0	0.0
4006R	2-8-96 Betaseed	4047	14.91	13.59	147	77.7	0.0

Mean  
LSD (.05)  
C.V. (%)  
F value

NOTE: See tests 1896 (nondiseased), 1596 (virus yellows), and 3596-1 & 3596-2 (rhizomania).

# TEST 2096. PERFORMANCE OF MONOGERM POPULATIONS AND BREEDING LINES, 1996

24 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: September 25, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Root Rot %
		Sugar	Beets				
		Lbs	Tons				
<u>Conversion of Popn-790 to Resistance to Rhizomania</u>							
0790	8790-S <sub>1</sub> (C)aa x A, C790	9233	33.81	148	13.64	81.6	0.0
4890m	RZM 3890mmaa x A, C890, Rz	10543	37.55	143	14.05	81.3	0.4
5890	3890-#S <sub>1</sub> (C)mmaa x A, C890-1, Rz	9997	34.55	153	14.46	81.4	0.0
5822m	4265-4279mmaa x A, C890-# comp.	10391	38.25	163	13.54	81.7	0.3
5822mA	Inc. 4265-4279mmA, C890-# comp.	9435	33.32	151	14.14	80.4	0.0
5812	RZM 4275, C890-2/3, WB41/42	10059	35.37	150	14.18	80.8	0.8
5814	RZM 4267, C890-4, PI07	9204	35.00	146	13.13	80.7	0.4
5815	RZM 4265, C890-5, R04	9022	32.08	146	14.09	79.8	0.0
5817	RZM 4268,77,P; C890-6/7, SES & R05	9276	33.40	149	13.89	79.6	0.0
5818	RZM 4270,72; C890-8, R22	9168	32.50	143	14.09	80.3	0.0
5819	RZM 4273, C890-9, WB151	9986	36.66	137	13.64	81.5	0.0
5820	RZM 4278,9,P; C890-10/11, WB169/258	9162	33.63	154	13.66	80.2	0.4
<u>Monogerm conversions of M- Popns</u>							
R540-1	RZM R440-1R, C37 x C79-#(C)	10511	36.25	145	14.51	80.6	0.0
5911-4-7CMS	4911-4H50 x T-O 4911-4-7mm	11066	40.03	149	13.84	78.8	0.0
5911-4mA	RZM 4911-4mmA (tagged)	9786	34.44	129	14.21	79.9	0.0
5911-4H87	4890m,aa x RZM 4911-4m	11900	43.00	151	13.86	78.5	0.0
<u>Monogerm Populations</u>							
5810	0790mmaa x 4265-4279 (C890-# comp.)	10318	36.55	152	14.11	81.4	0.0
5811	4890mmaa x 4265-4279 (C890-# comp.)	10559	37.10	158	14.23	81.0	0.0
5869	3867-#(C)mmaa x 3890-#(C)	10809	37.80	153	14.29	81.4	0.0
5834	RZM 4834, 3894 x mm, O-T	10318	36.13	146	14.29	80.9	0.0
5859%	RZM-#S 3859m(Sp)	8889	31.00	149	14.36	79.9	0.0
5893	RZM 4893(A,aa), 800Rz(C)aa x mm, O-T	9717	35.55	152	13.66	79.7	0.4
5895	RZM 4895, 4833; 867aa x 790 & mm, O-T	9162	33.75	151	13.55	80.2	0.0
5867(T-O)	T-O sel. 4867-#'s (A,aa)	7518	26.96	148	13.93	80.0	0.4
Mean		9834.6	35.20	148.7	13.97	80.5	0.1
LSD (.05)		852.6	2.74	12.4	0.57	1.8	0.6
C.V. (%)		8.8	7.89	8.5	4.14	2.3	492.3
F value		8.6**	10.46**	2.3**	2.78**	1.7*	1.0NS

NOTE: See tests 4496, 4596, & 5796 for performance under rhizomania.

TEST 4496. RHIZOMANIA EVALUATION OF MONOGERM LINES, BLOCK 2S, SALINAS, CA., 1996

16 entries x 4 replications (sequential)  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 8, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
		Sugar Lbs	Beets Tons				
0790	8790-S <sub>1</sub> (C)aa x A, (C790)	5631	21.53	13.00	179	79.3	4.8
5811	4890mmaa x 4265-4279	7677	27.51	13.95	168	77.9	5.3
0787	BYR-ER-PMR 8787	5535	22.78	12.13	191	78.9	4.5
5859%	RZM-%S 3859(Sp), (C859)	6760	24.99	13.52	158	76.1	7.0
5895	RZM 4895, 4833	7421	28.35	13.07	198	77.0	6.8
5822mA	Inc. 4265-4279mA	7031	26.15	13.48	194	77.7	5.5
5911-4(Iso)	NB-ER-RZM 3911-4;RZM-%S 3911-4	9705	31.71	15.30	166	78.5	4.5
5911-4H87	4890m,aa x RZM 4911-4m	10406	34.13	15.25	193	78.5	5.8
5911-4m	RZM 4911-4mmaa x A, (C911-4)	9593	31.50	15.23	146	79.0	5.0
5911-4-7CMS	4911-4H50 x T-O Sel. 4911-4-7mm	8963	32.05	14.00	205	78.5	5.0
4831	3911-4mmaa x mm, O-T(C)	9473	32.24	14.73	171	78.1	6.5
5867(T-O)	T-O Sel. 4867-#(C)	6942	24.68	14.05	189	78.9	6.3
5867NB	Inc. 3867-#(C)	7647	28.14	13.57	189	78.6	7.0
5864-8	T-O Sel. 4864-8-#(C)	3403	13.45	12.60	186	76.4	6.0
5864-14	T-O Sel. 4864-14-#(C)	6752	23.20	14.52	175	78.5	5.3
5864-34	T-O Sel. 4864-34-#(C)	7430	27.20	13.68	190	76.8	6.3
Mean		7523.1	26.85	13.88	181.0	78.0	5.7
LSD (.05)		1164.8	3.89	0.79	29.5	0.8	0.8
C.V. (%)		10.9	10.18	4.02	11.5	1.8	9.9
F value		19.8**	14.47**	11.54**	2.3*	1.9*	9.2**

NOTE: See tests 2096 (nondiseased) and 4596 & 5796 (rhizomania).

TEST 4596. PERFORMANCE OF MONOGERM POPULATIONS AND LINES, BLOCK 2S, SALINAS, CA., 1996

16 entries x 8 replications, RCB  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 8, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew Score
		Sugar Lbs	Beets Tons				
C890-# series							
0790	8790-S <sub>1</sub> (C)aa x A, C790	6819	25.53	13.38	194	79.6	6.0
4890m	RZM 3890mmaax A, C890, Rz	7755	27.46	14.11	179	79.3	6.3
5890	3890-#S <sub>1</sub> (C)mmaa x A, C890-1, Rz	7212	26.08	13.82	179	79.9	6.4
5822m	4265-4279mmaa x A, C890-#(C)	6715	25.20	13.30	200	78.7	6.5
5812	RZM 4275, C890-2/3, WB41/42	6895	25.60	13.48	188	79.3	6.9
5814	RZM 4267, C890-4, PI07	7012	27.82	12.52	183	79.4	6.4
5815	RZM 4265, C890-5, R04	7685	27.66	13.88	190	78.9	6.8
5817	RZM 4268,77,P; C890-6/7, SES & R05	6897	24.43	14.14	178	78.6	7.3
5818	RZM 4270,72, C890-8, R22	8028	28.20	14.25	190	79.2	6.5
5819	RZM 4273, C890-9, WB151	8252	30.17	13.68	187	80.0	6.8
5820	RZM 4278,9,P; C890-10/11, WB169,258	6481	24.71	13.10	179	77.7	6.3
5810	0790mmaa x 4265-4279	6566	24.85	13.23	195	78.4	6.5
5869	3867-#(C)mmaa x 3890-#(C)	8781	30.29	14.50	189	80.0	6.4
5834	RZM 4834(A,aa), 3894 x mm,O-T	8063	28.54	14.14	194	78.8	7.4
5893	RZM 4893(A,aa), 800Rz(C)aa x mm,O-T	8673	32.05	13.51	188	78.4	6.1
5911-4mA	RZM 4911-4mA (tagged), (C911-4)	9040	31.16	14.50	171	77.6	5.9
Mean		7554.6	27.48	13.72	186.4	79.0	6.5
LSD (.05)		818.4	2.66	0.61	19.6	1.7	0.6
C.V. (%)		10.9	9.78	4.46	10.6	2.2	9.1
F value		8.3**	6.63**	6.39**	1.2NS	1.5NS	3.9**

NOTE: See tests 2096 (nondiseased) and 4496 & 5796 (rhizomania).

TEST 5796. EVALUATION OF MONOGERM AND SELF-FERTILE LINES, FIELD C,  
SALINAS, CA., 1996

12 entries x 6 replications, (sequential)  
1-row plots, 12 ft. long

Planted: June 3, 1996  
Harvested: November 27, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %
		Sugar Lbs	Beets Tons			
0790	8790-S <sub>1</sub> (C)aa x A, C790	2396	11.33	10.63	157	75.8
5890	3890-#S <sub>1</sub> (C)mmaa x A, C890-1,Rz	2984	12.88	11.58	168	74.4
5810	0790mmaa x 4265-4279	2630	12.25	10.70	179	73.1
5822m	4265-4279mmaa x A, C890-#(C)	2780	12.83	10.90	186	73.7
5859%	RZM-%S 3859m(Sp), (C859)	2756	12.11	11.30	149	74.2
5895	RZM 4895, 4833	4055	18.28	11.15	160	74.3
5834	RZM 4834(A,aa), 3894 x mm, O-T	4043	17.42	11.62	157	74.4
5893	RZM 4893(A,aa), 800Rz(C)aa x mm, O-T	4540	20.80	10.90	158	73.3
5867NB	Inc. 3867-#(C), (C911-4)	3119	13.71	11.35	164	75.9
5911-4m	RZM 4911-4mmaa x A	4546	19.07	11.93	140	73.5
5911-4-7	T-O-Sel. 4911-4-7mm	2793	11.66	12.02	158	73.6
5913-70	RZM 3913-70 (C913-70)	2822	11.29	12.48	186	74.0
Mean		3288.7	14.47	11.38	163.5	74.2
LSD (.05)		673.7	2.83	0.79	24.4	2.5
C.V. (%)		17.7	16.87	6.02	12.9	2.9
F value		10.7**	11.76**	4.14**	2.7**	1.0NS

NOTE: See tests 2096 (nondiseased) and 4496 & 4596 (rhizomania).

# TEST 1996. PERFORMANCE OF NEAR-ISOLINES OF C37 WITH RESISTANCE TO RHIZOMANIA, 1996

24 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: September 26, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Bolting %
		Sugar	Beets				
		Lbs	Tons				
Checks							
US H11	L113401, 11-16-94	9560	34.36	150	13.90	82.3	0.0
Rizor	SES Lot F291, 2-13-96	11598	36.15	143	16.04	79.2	0.0
RR522 (Sp)	RZM R22(C), C51	9654	35.08	136	13.75	77.4	1.4
RR526	RZM R426R, F <sub>2</sub> (C37 x Bm)	7740	27.91	139	13.86	78.0	1.3
C79-# near-isolines							
U86-37	Inc. C37, 86443	8053	28.38	129	14.18	80.7	0.0
RR579	RZM R479(Iso), Inc. C79-1(Rz)	8921	33.22	112	13.43	78.9	0.0
RR524	RZM R424(Iso), Inc. C79-2(WB41)	9873	33.05	135	14.93	80.7	0.0
RR525	RZM R425(Iso), Inc. C79-3(WB42)	9097	32.01	139	14.21	79.7	0.0
RR528	RZM R428(Iso), Inc. C79-4(PI07)	9902	32.75	140	15.04	83.5	0.0
RR532	RZM R432(Iso), Inc. C79-5(R04)	9131	33.20	147	13.75	78.1	0.8
RR534	RZM R434(Iso), Inc. C79-6(R05)	9336	33.10	139	14.06	79.6	0.0
RR535	RZM R435(Iso), Inc. C79-7(SES)	10250	34.47	134	14.86	79.9	0.0
RR536	RZM R436(Iso), Inc. C79-8(R22)	9256	33.93	143	13.63	78.3	0.0
RR537	RZM R437(Iso), Inc. C79-9(WB151)	9789	33.57	139	14.59	80.4	0.0
RR541	RZM R441(Iso), Inc. C79-10(WB169)	8895	31.33	137	14.19	79.2	0.0
RR542	RZM R442(Iso), Inc. C79-11(WB258)	10340	36.70	137	14.09	80.0	0.0
One additional BC to C37							
RR545	RZM 4201, F <sub>2</sub> (C37 x C79-5)(R04)	9128	31.15	154	14.65	79.7	0.0
RR546	RZM 4243, F <sub>2</sub> (C37 x C79-8)(R22)	9527	33.83	136	14.06	80.0	0.0
RR548	RZM 4248, F <sub>2</sub> (C37 x C79-10)(WB169)	9892	34.62	148	14.26	80.6	0.0
RR549	RZM 4249, F <sub>2</sub> (C37 x C79-11)(WB258)	9367	31.91	139	14.69	80.8	0.0
RR550	RZM 4247, F <sub>2</sub> (C37 x C79-9)(WB151)	9248	31.93	152	14.48	79.5	0.0
RR540-1	RZM R440-1R, F <sub>2</sub> (C37 x C79PX)	9881	34.94	151	14.15	79.9	0.0
RR540%(Iso)	RZM-8S 3201-3285, (C79PX)	10211	35.20	148	14.51	79.5	0.0
5822m	4265-4279mmaa x A; C890-#(C)	9805	35.70	142	13.74	78.2	0.0
Mean		9518.9	33.27	149.3	14.29	79.8	0.1
LSD (.05)		815.6	2.22	12.0	0.59	2.4	0.7
C.V. (%)		8.7	6.77	8.7	4.17	3.0	503.2
F value		6.8**	7.38**	4.0**	7.26**	2.6**	2.5**

NOTE: See tests 3996 and 6096 for performance under rhizomania. See tests 2296, 4296, and 6196 for hybrid performance of these lines.



TEST 3996. PERFORMANCE UNDER RHIZOMANIA OF C79 NEAR-ISOLINES WITH RESISTANCE TO RHIZOMANIA, BLOCK 2S,  
SALINAS, CA., 1996

32 entries x 8 reps, RCB (equalized)  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: November 7, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Bolting %
		Sugar Lbs	Beets Tons				
<u>Checks</u>							
US H11	L113401, 11-16-94	5859	22.10	13.23	177	79.5	0.0
Rizor	SES Lot F291, 2-13-96	11264	33.57	16.80	183	79.5	0.0
R522(Sp)	RZM R22(C), C51	10186	36.49	13.98	164	78.1	0.0
R526	RZM R426R, F <sub>2</sub> (C37 x Bm)	7095	25.07	14.18	178	76.8	0.0
<u>C79-# near-isolines</u>							
U86-37	Inc. C37, 86443	5496	19.67	14.01	169	79.2	0.0
R579	RZM R479(Iso), Inc. C79-1(Rz)	7621	27.53	13.85	151	78.7	0.0
R524	RZM R424(Iso), Inc. C79-2(WB41)	8418	28.45	14.81	183	78.4	0.0
R525	RZM R425(Iso), Inc. C79-3(WB42)	7166	24.60	14.60	179	78.8	0.3
R528	RZM R428(Iso), Inc. C79-4(PI07)	6927	24.02	14.41	182	79.8	0.0
R532	RZM R432(Iso), Inc. C79-5(R04)	7040	26.48	13.31	182	78.2	0.0
R534	RZM R434(Iso), Inc. C79-6(R05)	8201	27.57	14.88	163	79.3	0.0
R535	RZM R435(Iso), Inc. C79-7(SES)	9172	30.52	15.01	181	78.6	0.0
R536	RZM R436(Iso), Inc. C79-8(R22)	8572	30.48	14.10	184	77.4	0.6
R537	RZM R437(Iso), Inc. C79-9(WB151)	7876	25.99	15.18	173	79.7	0.0
R541	RZM R441(Iso), Inc. C79-10(WB169)	7364	26.64	13.86	171	78.5	0.0
R542	RZM R442(Iso), Inc. C79-11(WB258)	8657	30.26	14.29	165	79.6	0.0
<u>One additional BC to C37</u>							
R545	RZM 4201, F <sub>2</sub> (C37 x C79-5)(R04)	7293	24.84	14.70	181	80.7	0.0
R546	RZM 4243, F <sub>2</sub> (C37 x C79-8)(R22)	8126	29.43	13.80	161	77.3	0.0
R548	RZM 4248, F <sub>2</sub> (C37 x C79-10)(WB169)	7124	25.98	13.75	179	78.9	0.0
R549	RZM 4249, F <sub>2</sub> (C37 x C79-11)(WB258)	7610	26.37	14.42	178	79.5	0.8
R550	RZM 4247, F <sub>2</sub> (C37 x C79-9)(WB151)	7472	26.08	14.38	181	77.4	0.0
R540-1	RZM R440-1R, F <sub>2</sub> (C37 x C79PX)	7890	27.31	14.46	171	79.3	0.0
R540%(Iso)	RZM-8S 3201-3285, (C79PX)	9546	32.62	14.65	190	78.3	0.0
R540(Sp)	RZM R40(C), RZM C79-#(C)	9114	32.46	14.04	167	78.1	0.8

TEST 3996. PERFORMANCE UNDER RHIZOMANIA OF C79 NEAR-ISOLINES WITH RESISTANCE TO RHIZOMANIA, BLOCK 2S,  
SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Bolting %
		Sugar	Beets				
		Lbs	Tons				
<u>Lines with C79-#(C) combined resistance</u>							
R551	U86-37 x RZM R40(C)	7746	27.19	14.25	174	79.2	0.0
Y564(Iso)	RZM 4205,P;4206,P;4207,P;4208,P	10601	35.27	15.06	173	79.5	0.0
Y565(Iso)	RZM 4280,P;4284,P	10420	36.07	14.48	178	78.5	0.0
R578(Sp)	RZM R478NB, C78	9769	30.76	15.93	169	81.6	0.0
5922	RZM R440H18	8901	30.73	14.54	172	79.7	0.0
5923	4918aa x RZM R40(C)	9581	32.86	14.56	177	79.3	0.0
5822M	4265-4279Maa x A, (C890-#'s comp.)	7963	28.85	13.79	174	80.4	0.0
5810	0790mmaa x 4265-4269, (C790 x " )	7708	27.48	14.00	177	80.4	0.0
Mean		8243.0	28.55	14.42	174.6	79.0	0.1
LSD (.05)		834.8	2.74	0.58	16.0	1.7	0.6
C.V. (%)		10.3	9.76	4.06	9.3	2.2	780.1
F value		19.9**	16.04**	11.48**	2.0**	2.8**	1.1NS

NOTE: See test 1996 (nondiseased) and 6096 (severe rhizomania). Y564 is 25% B.maritima;  
Y565 is about 6% B.m.

TEST 6096. RHIZOMANIA EVALUATION OF C79-# & C890-# LINES, FIELD C, SALINAS, CA., 1996

32 entries x 8 replications, RCB (equalized)  
1-row plots, 21 ft. long

Planted: June 3, 1996  
Harvested: November 5, 1996

Variety	Description	Acre Yield		Beets/ 100'	RJAP %
		Sugar Lbs	Beets Tons		
<u>Checks</u>					
US H11	L113401, 11-16-94	1409	7.57	9.35	177
Rizor	F291, 2-13-96	4075	14.67	13.88	160
R522(Sp)	RZM R22(C), C51	4055	17.63	11.44	157
5923	4918aa x RZM R40(C)	3566	14.90	11.95	145
<u>C79-# near-isolines</u>					
U86-37	Inc. C37, 86443	1602	7.27	11.01	143
R579	RZM R479, Inc. C79-1 (Rz)	3181	13.94	11.39	159
R524	RZM R424, Inc. C79-2 (WB41)	3013	12.23	12.31	142
R525	RZM R425, Inc. C79-3 (WB42)	2048	9.03	11.36	152
R528	RZM R428, Inc. C79-4 (PI07)	2338	9.78	11.93	161
R532	RZM R432, Inc. C79-5 (R04)	2347	11.08	10.63	162
R534	RZM R434, Inc. C79-6 (R05)	2797	12.08	11.56	161
R535	RZM R435, Inc. C79-7 (SES)	3735	14.68	12.69	165
R536	RZM R436, Inc. C79-8 (R22)	3533	15.90	11.13	151
R537	RZM R437, Inc. C79-9 (WB151)	3116	12.10	12.85	164
R541	RZM R441, Inc. C79-10 (WB169)	2857	12.08	11.76	157
R542	RZM R442, Inc. C79-11 (WB258)	3332	14.37	11.64	154
<u>Additional backcrosses to C37</u>					
R545	RZM 4201, F <sub>2</sub> (C37 x C79-5) (R04)	2482	10.52	11.80	172
R546	RZM 4243, F <sub>2</sub> (C37 x C79-8) (R22)	3683	15.77	11.69	154
R548	RZM 4248, F <sub>2</sub> (C37 x C79-10) (WB169)	2513	10.86	11.55	154
R549	RZM 4249, F <sub>2</sub> (C37 x C79-11) (WB258)	2815	11.45	12.26	159

TEST 6096. RHIZOMANIA EVALUATION OF C79-# & C890-# LINES, FIELD C, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %
		Sugar	Beets			
		Lbs	Tons			
<u>Additional backcrosses to C37 (cont.)</u>						
R550	RZM 4247, F <sub>2</sub> (C37 x C79-9) (WB151)	2332	10.02	11.59	158	71.7
R540-1	RZM R440-1R, F <sub>2</sub> (C37 x C79PX)	2661	11.89	11.23	175	70.7
R540%(Iso)	RZM-8S 3201-3285, C79PX	3491	14.82	11.75	155	73.5
Y564(Iso)	RZM 4205-4208, F <sub>2</sub> (C37 x R322Y3)	4538	17.94	12.63	162	74.2
<u>C890-# near-isolines</u>						
5890	3890-#S <sub>1</sub> (C) <sub>mmaa</sub> x A, C890-1 (Rz)	2948	12.38	11.93	173	75.3
5812	RZM 4275, C890-2/3 (WB41/42)	2532	10.93	11.44	177	74.5
5815	RZM 4265, C890-5 (R04)	2728	11.58	11.79	165	74.9
5817	RZM 4268,77,P; C890-6/7 (SES, R05)	2833	11.58	12.23	165	76.0
5818	RZM 4270,72; C890-8 (R22)	2935	12.35	11.90	168	77.6
5819	RZM 4273, C890-9 (WB151)	3290	13.77	11.94	170	77.3
5820	RZM 4278,9,P; C890-10/11 (WB169/258)	2267	10.63	10.70	158	71.7
5869	3867-#(C) <sub>mmaa</sub> x 3890-#(C)	3807	16.08	11.81	173	77.7
Mean		2964.3	12.56	11.72	160.9	73.7
LSD (.05)		455.2	1.71	0.67	19.8	2.5
C.V. (%)		15.6	13.79	5.78	12.5	3.5
F value		18.9**	18.44**	10.26**	1.7*	4.9**

NOTE: See test 1996 (nondiseased) and 3996 (rhizomania).

# TEST 2296. PERFORMANCE OF C79-# HYBRIDS, 1996

24 entries x 8 reps, RCB (equalized)  
 1-row plots, 18 + 3 ft. long (24 blocks, 8 rows)

Planted: April 15, 1996  
 Harvested: September 19, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Root Rot %
		Sugar Lbs	Beets Tons				
6770	high %S check, 2-8-96	9727	31.52	15.50	146	81.7	0.5
4454	Comm. check, 4002 (4-28-95)	9133	31.70	14.43	141	81.6	0.0
US H11	L113401, 11-16-94	8337	31.04	13.41	151	79.9	0.0
Rizor	SES F291, 2-13-96	10219	31.48	16.24	137	80.4	0.0
SS-781R	Spreckels 941000, 8-21-95	9380	33.10	14.20	130	80.6	0.0
4006R	Betaseed, 2-8-96	8380	26.88	15.57	117	81.1	0.0
R522H50	F92-790-15CMS x RZM R22(C)	9598	35.00	13.75	133	78.8	0.0
R578H50	F92-790-15CMS x RZM R478NB	9766	34.05	14.36	151	81.7	0.0
R479H50(Iso)	F92-790-15CMS x RZM R379, C79-1(Rz)	9314	32.75	14.20	144	79.5	0.0
R579H50	F92-790-15CMS x RZM R479, C79-1(Rz)	9112	32.40	14.04	147	80.7	0.0
R524H50	F92-790-15CMS x RZM R424, C79-2(WB41)	9288	32.75	14.18	149	80.6	0.0
R525H50	F92-790-15CMS x RZM R425, C79-3(WB42)	9258	33.08	13.99	143	79.9	0.0
R528H50	F92-790-15CMS x RZM R428, C79-4(PI07)	9428	34.25	13.74	158	79.9	0.0
R532H50	F92-790-15CMS x RZM R432, C79-5(R04)	9695	35.06	13.81	141	79.4	0.0
R534H50	F92-790-15CMS x RZM R434, C79-6(R05)	9107	33.17	13.68	154	80.8	0.0
R535H50	F92-790-15CMS x RZM R435, C79-7(SES)	10045	33.68	14.91	145	80.6	0.0
R536H50	F92-790-15CMS x RZM R436, C79-8(R22)	9503	34.05	13.96	145	79.3	0.0
R537H50	F92-790-15CMS x RZM R437, C79-9(WB151)	9500	33.16	14.35	150	81.0	0.0
R541H50	F92-790-15CMS x RZM R441, C79-10(WB169)	8880	31.32	14.18	138	80.7	0.0
R542H50	F92-790-15CMS x RZM R442, C79-11(WB258)	9425	33.65	14.05	138	79.8	0.0
R540H50	F92-790-15CMS x RZM R40(C)	9580	34.71	13.79	142	80.0	0.0
5921H50	F92-790-15CMS x RZM R21(C)	9763	34.70	14.05	139	79.0	0.0
R543R2H50	F92-790-15CMS x RZM R443	10120	34.92	14.50	134	80.9	0.8
R581H50	F92-790-15CMS x RZM R481-43,-89,(C82)	10112	35.70	14.20	142	81.1	0.0
Mean		9444.6	33.09	14.30	142.2	80.4	0.1
LSD (.05)		752.7	2.42	0.54	15.5	1.5	0.4
C.V. (%)		8.1	7.44	3.81	11.1	1.8	780.0
F value		3.2**	4.62**	11.73**	2.3**	2.5**	1.7*

NOTE: See tests 4296 and 6196 for performance under rhizomania.  
 See tests 1996, 3996, and 6096 for performance of the lines per se.

TEST 4296. PERFORMANCE OF C79-# HYBRIDS UNDER RHIZOMANIA, BLOCK 2S, SALINAS, CA., 1996

16 entries x 8 replications, RCB  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 15, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew	
		Sugar Lbs	Beets Tons				Score	Score
R522H50	F92-790-15CMS x RZM R22(C) (C51)	10050	38.82	12.93	181	77.2		6.9
R578H50	F92-790-15CMS x RZM R478NB (C78)	9481	35.78	13.28	195	79.3		6.6
Rizor	F291, 2-13-96	9719	31.81	15.28	180	78.2		8.3
US H11	L113401, 11-16-94	5364	24.11	11.14	193	78.9		8.5
R579H50	F92-790-15CMS x RZM R479, C79-1(Rz)	8909	33.22	13.41	182	79.7		7.3
R524H50	F92-790-15CMS x RZM R424, C79-2(WB41)	8372	32.05	13.03	186	78.3		7.1
R525H50	F92-790-15CMS x RZM R425, C79-3(WB42)	7240	29.40	12.27	176	78.9		7.3
R528H50	F92-790-15CMS x RZM R428, C79-4(PI07)	7642	30.20	12.68	181	79.9		7.5
R532H50	F92-790-15CMS x RZM R432, C79-5(R04)	8604	33.39	12.88	189	77.5		7.8
R534H50	F92-790-15CMS x RZM R434, C79-6(R05)	8364	32.34	12.93	195	80.2		7.6
R535H50	F92-790-15CMS x RZM R435, C79-5(SES)	8931	32.40	13.79	176	79.1		7.1
R536H50	F92-790-15CMS x RZM R436, R79-8(R22)	9007	34.67	12.97	172	77.2		7.1
R537H50	F92-790-15CMS x RZM R437, C79-9(WB151)	7962	29.95	13.28	177	79.1		7.3
R541H50	F92-790-15CMS x RZM R441, C79-10(WB169)	8658	33.16	13.07	168	78.6		7.0
R542H50	F92-790-15CMS x RZM R442, C79-11(WB258)	9015	34.64	13.05	166	78.9		6.8
R540H50	F92-790-15CMS x RZM R40(C)	8465	32.05	13.19	174	77.9		7.3
Mean		8486.5	32.38	13.08	180.5	78.7		7.3
LSD (.05)		873.8	3.18	0.48	15.3	1.9		0.6
C.V. (%)		10.4	9.90	3.71	8.6	2.4		7.8
F value		12.5**	8.01**	23.16**	2.8**	1.9*		6.2**

NOTES: See tests 2296 (nondiseased) and 6196 (severe rhizomania).

TEST 6196. RHIZOMANIA EVALUATION OF C79-# HYBRIDS, FIELD C, SALINAS, CA., 1996

16 entries x 8 replications, RCB (equalized)  
1-row plots, 21 ft. long

Planted: June 3, 1996  
Harvested: November 5, 1996

Variety	Description	Acre Yield		Beets/ 100'	RJAP %
		Sugar Lbs	Beets Tons		
R522H50	F92-790-15CMS x RZM R22(C) (C51)	4455	18.65	142	75.0
R578H50	F92-790-15CMS x RZM R478NB (C78)	3602	14.49	171	78.9
Rizor	F291, 2-13-96, SES	3633	12.91	172	75.4
US H11	L113401, 11-16-94	1215	7.08	187	70.1
R579H50	F92-790-15CMS x RZM R479, C79-1 (Rz)	3695	15.88	174	75.5
R524H50	F92-790-15CMS x RZM R424, C79-2 (WB41)	2828	11.90	177	75.0
R525H50	F92-790-15CMS x RZM R425, C79-3 (WB42)	2259	10.53	152	72.4
R528H50	F92-790-15CMS x RZM R428, C79-4 (PI07)	1954	9.07	174	75.3
R532H50	F92-790-15CMS x RZM R432, C79-5 (R04)	3027	13.33	176	73.6
R534H50	F92-790-15CMS x RZM R434, C79-6 (R05)	2869	12.93	181	75.5
R535H50	F92-790-15CMS x RZM R435, C79-7 (SES)	3141	12.88	167	75.3
R536H50	F92-790-15CMS x RZM R436, C79-8 (R22)	3885	17.38	127	74.2
R537H50	F92-790-15CMS x RZM R437, C79-9 (WB151)	2840	12.55	155	73.4
R541H50	F92-790-15CMS x RZM R441, C79-10 (WB169)	3068	13.82	177	74.3
R542H50	F92-790-15CMS x RZM R442, C79-11 (WB258)	3156	13.98	156	74.9
R540H50	F92-790-15CMS x RZM R40(C)	3503	15.32	157	75.0
Mean		3070.6	13.29	165.3	74.6
LSD (.05)		365.7	1.53	19.9	2.5
C.V. (%)		12.0	11.63	12.2	3.4
F value		36.2**	27.95**	5.0**	4.1**

NOTES: See tests 2296 (nondiseased) and 4296 (rhizomania).

# TEST 1796. PERFORMANCE OF POPULATIONS WITH BETA MARITIMA GERMPLASM, SALINAS, CA., 1996

12 entries x 8 reps, RCB  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: October 3, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Bolting %	Root Rot %
		Sugar Lbs	Beets Tons					
R22 (C50, C51) lines								
R722	Inc. F <sub>2</sub> (Y54xBm) (C50); Cycle 0 Source	9139	34.06	13.45	146	77.0	6.4	0.5
Y522Y4	RZM-8S R322Y3, Y3%; Cycle 4 for VYR/RZM	10488	35.70	14.66	142	78.6	0.0	0.0
R522R5	RZM-8S R322R4, R4%; Cycle 5 for RZM	9493	33.62	14.11	137	77.0	0.0	1.0
R522(Sp)	RZM-8S R22R/R22Y comp.; Cycle 5 (C51)	9913	35.47	13.95	145	77.1	0.4	0.0
Backcross lines (S'S')								
Y562	RZM Y462R; Y#rr(C) x R#R(C); Rz line	10670	35.77	14.91	146	79.8	0.0	0.4
Y564	RZM 4205, P; ...; BC <sub>1</sub> F <sub>2</sub> 25% Bm	10390	34.55	15.04	140	79.4	0.0	0.8
R543R2	RZM R443; BC <sub>2</sub> F <sub>3</sub> 12% Bm	11128	38.63	14.40	133	79.2	0.0	0.0
Y565	RZM 4280, P; 4284, P; BC <sub>3</sub> F <sub>2</sub> 6% Bm	10692	37.55	14.24	149	79.5	0.0	0.0
Backcross lines (S', Aa)								
5915	RZM 4911, 4915, 4916, 4918aa x A; Rz line	10937	37.70	14.52	132	80.0	0.0	0.0
5921	RZM R422R4H15, H17; Y3H15; BC <sub>1</sub> F <sub>2</sub> 25% Bm	10572	36.45	14.51	132	78.6	0.0	0.0
R544R2	RZM R444; BC <sub>2</sub> F <sub>3</sub> 12% Bm	10757	37.67	14.30	138	79.8	0.0	0.5
5920	RZM 4287; BC <sub>3</sub> F <sub>2</sub> 6% Bm	10631	37.74	14.09	136	79.5	0.0	0.0
Mean		10400.8	36.24	14.35	139.7	78.8	0.6	0.3
LSD (.05)		988.6	3.31	0.45	11.6	1.7	1.3	1.1
C.V. (%)		9.6	9.16	3.14	8.3	2.2	232.2	418.3
F value		2.8**	1.95*	7.36**	2.1*	3.7**	15.4**	0.9NS

NOTES: See tests 1496 (virus yellows) and 3696 & 5896 (rhizomania).

Resistance to rhizomania has been identified in Beta vulgaris spp. maritima. The highest level of resistance identified is in breeding lines R22 (R522, R522R5, R522Y4) (C50, C51) that are 50% sugarbeet and 50% Bvm. This interspecific population has been improved by multiple cycles of selection for resistance to rhizomania (R522 & R522R5) and for resistance to virus yellows (R522 & R522Y4). R22 is being used as the donor parent in backcrosses to introgress resistance into sugarbeet. Included in the descriptions above is the approximate % Bvm left in each line.



TEST 1496. PERFORMANCE OF POPULATIONS WITH BETA MARITIMA GERMPLASM UNDER VIRUS YELLOWS CONDITIONS,  
SALINAS, CA., 1996

12 entries x 8 reps, RCB  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: October 3, 1996  
BYV/BWV Inoc.: June 4, 1996

Variety	Description	Acre Yield		Beets/ 100'	RJAP %	Bolting %	Virus	
		Sugar Lbs	Beets Tons				No.	Mean
R22 (C50, C51) lines								
R722	Inc.F <sub>2</sub> (Y54 x B <sub>m</sub> )(C50); Cycle 0 Source	7179	27.45	13.07	146	75.9	5.3	4.3
Y522Y4	RZM-%S R322Y3, Y3%; Cycle 4 for BYV/RZM	7792	27.26	14.29	142	77.8	0.5	3.7
R522R5	RZM-%S R322R4, R4%	6537	25.61	12.75	149	74.0	1.6	4.7
R522(Sp)	RZM-%S R22R & R22Y(C) (C51)	7031	26.65	13.20	148	75.2	0.0	4.6
Backcross lines (S'S')								
Y562	RZM Y462R; Y#rr(C) x R#R(C); Rz line	7954	28.50	13.94	144	78.9	0.0	4.0
Y564	RZM 4205, P; ...	7803	27.17	14.35	147	78.2	0.0	3.4
R543R2	RZM R443	7352	27.40	13.41	137	77.1	0.0	3.8
Y565	RZM 4280, P; 4284, P	7968	29.10	13.68	143	78.1	0.0	4.2
Backcross lines (S', Aa)								
5915	RZM 4911, 4915, 4916, 4918aa x A; Rz line	7877	28.89	13.63	133	78.4	0.0	4.0
5921	RZM R422R4H15, H17; Y3H15	7674	27.65	13.86	137	76.9	0.0	3.8
R544R2	RZM R444	7319	26.76	13.69	135	78.1	0.0	4.0
5920	RZM 4287	7660	28.00	13.68	133	79.7	0.0	3.5
Mean		7512.1	27.54	13.63	141.3	77.4	0.6	4.0
LSD (.05)		578.4	1.64	0.53	8.8	1.9	1.7	0.4
C.V. (%)		7.7	5.99	3.92	6.2	2.5	280.8	10.1
F value		4.5**	2.88**	6.18**	3.6**	5.7**	6.4**	7.7**

NOTES: See tests 1796 (nondiseased) and 3696 & 5896 (rhizomania).

Resistance to rhizomania has been identified in Beta vulgaris spp. maritima. The highest level of resistance identified is in breeding lines R22 (R522, R522R5, R522Y4) (C50, C51) that are 50% sugarbeet and 50% Bvm. This interspecific population has been improved by multiple cycles of selection for resistance to rhizomania (R522 & R522R5) and for resistance to virus yellows (R522 & R522Y4). R22 is being used as the donor parent in backcrosses to introgress resistance into sugarbeet. Included in the descriptions above is the approximate % Bvm left in each line.

TEST 3696. PERFORMANCE UNDER RHIZOMANIA OF POPULATIONS WITH BETA MARITIMA GERMPASM, BLOCK 2S,  
SALINAS, CA., 1996

16 entries x 8 replications, RCB  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 16, 1996

Variety	Description	Acre Yield		Beets/ 100'	Bolters %	Powdery Mildew	
		Sugar Lbs	Beets Tons			Sucrose %	Score
Checks							
US H11	L113401, 11-16-94	4714	19.40	12.15	0.0	8.4	80.9
Rizor	F291, 2-13-96	9052	28.66	15.78	0.0	7.5	78.2
R522H50	F92-790-15CMS x RZM R522(C) (C51)	9275	34.50	13.49	0.0	7.0	79.0
R22 (C50,C51) lines							
R722	Inc. F <sub>2</sub> (Y54xBm) (C50); Cycle 0 Source	6020	23.63	12.77	8.4	6.3	76.3
Y522Y4	RZM-%S R322Y3,Y3%; Cycle 4 for VYR/RZM	8248	29.95	13.79	0.0	5.9	79.0
R522R5	RZM-%S R322R4,R4%; Cycle 5 for RZM	8673	32.22	13.44	0.3	7.5	76.6
R522(Sp)	RZM-%S R22R/R22Y(C); Cycle 4-6(C51)	8214	31.04	13.24	0.4	7.0	76.6
Backcross lines (S'S')							
Y562	RZM Y462R; Y#rr(C) x R#R(C), Rz line	7547	27.96	13.55	0.0	6.1	80.9
Y564	RZM 4205,P;...;BC <sub>1</sub> F <sub>2</sub> 25% Bm	8722	30.65	14.21	0.0	6.0	79.7
R543R2	RZM R443; BC <sub>1</sub> F <sub>3</sub> 12% Bm	8021	29.96	13.40	0.0	7.1	77.6
Y565	RZM 4280,P; 4284,P; BC <sub>3</sub> F <sub>2</sub> 6% Bm	8258	30.89	13.38	0.0	7.1	77.9
Backcross lines (S', Aa)							
5915	RZM 4911,4915,4916,4918aa x A;Rz line	8870	32.53	13.68	0.0	6.4	79.3
5921	RZM R422R4H15,H17;Y3H15;BC <sub>1</sub> F <sub>2</sub> 25%Bm	8348	31.37	13.29	0.0	6.9	77.9
R544R2	RZM R444; BC <sub>2</sub> F <sub>3</sub> 12% Bm	7829	29.65	13.20	0.0	6.6	78.9
5920	RZM 4287; BC <sub>3</sub> F <sub>2</sub> 6% Bm	8673	31.87	13.61	0.0	6.9	80.7
5921H18	4918aa x RZM R21(C);BC <sub>2</sub> F <sub>1</sub> 12%Bm	8686	31.35	13.86	0.0	6.3	79.2
Mean		8072.0	29.73	13.55	180.5	6.8	78.7
LSD (.05)		840.7	3.02	0.56	15.3	0.6	2.0
C.V. (%)		10.5	10.25	4.19	8.6	192.0	2.6
F value		15.3**	11.42**	14.05**	2.0*	29.4**	4.3**

**NOTES:** See tests 1796 (nondiseased), 1496 (virus yellows), and 5896 (severe rhizomania). Resistance to rhizomania has been identified in Beta vulgaris spp. maritima. The highest level of resistance identified is in breeding lines R22 (R522, R522R5, R522Y4) (C50, C51) that are 50% sugarbeet and 50% Bvm. This interspecific population has been improved by multiple cycles of selection for resistance to rhizomania (R522 & R522R5) and for resistance to virus yellows (R522 & R522Y4). R22 is being used as the donor parent in backcrosses to introgress resistance into sugarbeet. Included in the descriptions above is the approximate % Bvm left in each line.

TEST 5896. POPULATIONS WITH GERMPLASM FROM BETA MARITIMA, FIELD C,  
SALINAS, CA., 1996

16 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: June 3, 1996  
Harvested: December 2, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Bolting %
		Sugar Lbs	Beets Tons				
US H11	L113401, 11-16-94	1525	7.74	170	9.70	71.5	0.0
Rizor	F291, 2-13-96	3517	12.87	177	13.64	76.0	0.0
R526	RZM R426R, F <sub>2</sub> (C37 x B.m.)	1488	7.06	169	10.48	68.9	0.0
<u>R22 (C50, C51) lines</u>							
R722	Inc. F <sub>2</sub> (Y54 x B.m.)(C50); Cycle 0	2001	9.36	143	10.69	73.1	4.2
Y522Y4	RZM-%S R322Y3, Y3%; Cycle 4 for VYR/RZM	3903	15.17	160	12.89	74.5	0.0
R522R5	RZM-%S R322R4, R4%; Cycle 5 for RZM	3768	16.69	163	11.27	71.5	2.1
R522(Sp)	RZM-%S R22R/R22Y(C); Cycle 4-6 (C51)	4006	17.82	168	11.21	72.5	0.3
<u>Backcross lines (S'S')</u>							
Y562	RZM Y462R; Y#rr x R#R(C); Rz line	3402	13.75	165	12.27	75.6	0.0
Y564	RZM 4205,P;...;BC <sub>1</sub> F <sub>2</sub> 25% Bm	4317	17.04	162	12.66	73.5	0.0
Y565	RZM 4280-4284; BC <sub>3</sub> F <sub>2</sub> 6% Bm	4354	17.83	170	12.18	74.4	0.0
<u>Backcross lines (S', Aa)</u>							
5915	RZM 4911,...,4918aa x A, Rz line	3996	16.10	168	12.40	75.1	0.0
5921	RZM R422R4H15,H17,Y3H15;BC <sub>1</sub> F <sub>2</sub> 25% Bm	4387	17.41	160	12.54	75.4	0.4
R544R2	RZM R444; BC <sub>2</sub> F <sub>3</sub> 12% Bm	4124	17.75	159	11.56	74.9	0.0
5920	RZM 4287; BC <sub>3</sub> F <sub>2</sub> 6% Bm	3760	16.03	164	11.75	75.3	0.0
5921H18	4918aa x RZM R21(C); BC <sub>2</sub> F <sub>1</sub> 12% Bm	3923	15.70	175	12.46	74.4	0.0
5922	RZM R440H18	3392	13.89	158	12.20	74.4	0.0
Mean		3491.5	14.51	164.4	11.87	73.8	0.4
LSD (.05)		552.6	1.96	16.7	0.80	2.4	1.4
C.V. (%)		16.0	13.66	10.3	6.78	3.2	228.3
F value		23.6**	25.81**	1.8NS	12.50**	5.1**	
4.9**							

NOTES: See tests 1796 (nondiseased), 1496 (virus yellows), and 3696 (virus yellows).

Resistance to rhizomania has been identified in Beta vulgaris spp. maritima. The highest level of resistance identified is in breeding lines R22 (R522, R522R5, R522Y4) (C50, C51) that are 50% sugarbeet and 50% Bvm. This interspecific population has been improved by multiple cycles of selection for resistance to rhizomania (R522 & R522R5) and for resistance to virus yellows (R522 & R522Y4). R22 is being used as the donor parent in backcrosses to introgress resistance into sugarbeet. Included in the descriptions above is the approximate % Bvm left in each line.

# TEST 2196. PERFORMANCE OF EXPERIMENTAL HYBRIDS, 1996

48 entries x 8 reps, RCB (equalized); 3 subtests: 16 x 8, RCB(e) Planted: April 15, 1996  
 1-row plots, 21 ft. long Harvested: September 23, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Root Rot %
		Sugar	Beets				
		Lbs	Tons				
2196-1: Topcross Hybrids w/ C790-15CMS as Tester							
4454	Comm. check, 4002 (4-28-95) (BTS)	11043	38.15	14.46	133	82.2	0.0
6770	High %S check, 2-8-96 (KWS)	11284	36.12	15.64	142	82.9	0.4
RR479H50(Iso)	F92-790-15CMS x RZM R379 (C79-1,Rz)	10941	38.91	14.07	131	81.3	0.0
RR480-45H50	F92-790-15CMS x R280-45 (C80-45)	10989	38.50	14.29	145	80.4	0.4
RR578H50	F92-790-15CMS x RZM R478NB (C78)	11171	38.85	14.37	141	80.9	0.0
RR578H50-#	4790-15-#(C)CMS x RZM R478NB (C78)	11095	40.30	13.76	141	80.6	0.0
RR578H50-21	4790-15-21CMS x RZM R478NB (C78)	11084	41.08	13.51	149	80.6	0.0
RR578H50-23	4790-15-23CMS x RZM R478NB (C78)	11260	40.08	14.06	139	80.9	0.0
RR581H50	F92-790-15CMS x RZM R481-43,-89 (C82)	10923	39.45	13.84	147	81.7	0.4
RS76-89-18H50	F92-790-15CMS x R476-89-18 (C76-89-18)	10946	38.25	14.30	143	81.6	0.4
RS76-89-18H50	F92-790-15CMS x RZM R476-89-18 (C76-89-18)	11102	39.19	14.16	148	81.7	0.4
RS76-89-5H50	F92-790-15CMS x RZM R476-89-5 (C76-89-5)	12052	39.81	15.13	136	80.8	0.0
RS76-43-14H50	F92-790-15CMS x RZM R476-43-14 (C76-43-14)	10745	38.35	14.02	136	81.5	0.0
RS76-43-15H50	F92-790-15CMS x RZM R476-43-15 (C76-43-15)	10959	37.70	14.52	137	81.6	0.0
RS43R2H50	F92-790-15CMS x RZM R443	10703	37.72	14.18	137	79.7	0.0
US H11	L113401, 11-16-94	8862	33.25	13.32	145	81.0	0.0
Mean		10947.4	38.48	14.23	140.5	81.2	0.1
LSD (.05)		768.4	2.51	0.40	9.9	1.2	0.6
C.V. (%)		7.1	6.59	2.84	7.1	1.5	495.6
F value		5.3**	4.18**	15.61**	2.2*	3.2**	0.8NS

## TEST 2196. PERFORMANCE OF EXPERIMENTAL HYBRIDS, 1996

48 entries x 8 reps, RCB (equalized). ANOVA to compare means across sets of entries.

Mean	11010.1	38.63	14.26	141.7	80.9	0.1
LSD (.05)	816.6	2.64	0.39	11.3	1.2	0.6
C.V. (%)	7.5	6.94	2.77	8.1	1.5	622.1
F value	3.6**	5.07**	13.32**	3.4**	3.8**	0.8NS

NOTE: F92-790-15CMS = C790-68CMS x C790-15. 4790-15-#(C),-21,&-23 are from reselection of C790-15.

See tests 2396, 1696 (virus yellows), and 4196, 4396, & 6296 (rhizomania).

TEST 2196. PERFORMANCE OF EXPERIMENTAL HYBRIDS, 1996

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100'	RJAP %	Root Rot %
		Sugar Lbs	Beets Tons				
		2196-2: S',Aa Topcrosses w/ C790-15CMS as Tester					
Rizor	SES F291, 2-13-96	11353	35.50	16.00	140	79.6	0.0
4006R	Betaseed, 2-8-96	9890	32.04	15.43	112	80.8	0.6
4915H50	F92-790-15CMS x RZM 3915	10866	39.00	13.95	142	80.7	0.0
4918H50	F92-790-15CMS x RZM 3918 (C918)	11706	41.08	14.25	143	81.3	0.0
5911-4H50	F92-790-15CMS x RZM 4911-4m (C911-4)	12069	41.83	14.43	151	81.0	0.0
5911-4H50	F92-790-15CMS x NB-ER-RZM 3911-4 (C911-4)	12328	43.85	14.05	149	80.5	0.0
5913-70H50	F92-790-15CMS x RZM 3913-70 (C913-70)	11564	40.80	14.16	145	80.8	0.0
5913-71H50	F92-790-15CMS x RZM 4913-71	11783	43.03	13.69	145	80.7	0.0
4915-7H50	F92-790-15CMS x 3915-7	11223	37.90	14.80	140	81.0	0.0
5915H50	F92-790-15CMS x RZM-8S 3915	11197	39.15	14.31	148	80.4	0.0
R544R2H50	F92-790-15CMS x RZM R444	11050	39.35	14.04	147	80.7	0.0
R578H12	4911-4H50 x RZM R478NB (C78)	11017	37.83	14.57	137	81.6	0.0
R578H11	4911-4#M(C)aa x RZM R478NB (C78)	10503	37.40	14.03	139	80.4	0.0
R540H50	F92-790-15CMS x RZM R40(C)	10901	39.61	13.76	144	80.2	0.0
R522H50	F92-790-15CMS x RZM R22(C) (C51)	11056	39.46	13.99	137	78.3	0.4
5921H50	F92-790-15CMS x RZM R21(C)	11449	40.35	14.18	145	80.1	0.0
Mean		11247.2	39.26	14.35	141.5	80.5	0.1
LSD (.05)		759.5	2.54	0.36	11.6	1.0	0.5
C.V. (%)		6.8	6.54	2.51	8.3	1.2	819.2
F value		4.8**	9.91**	22.90**	4.4**	4.6**	0.9NS

NOTES: 4911-4H50 = C790-15CMS x C911-4  
4911-4#M = C911-4aa

TEST 2196. PERFORMANCE OF EXPERIMENTAL HYBRIDS, 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	RJAP	Root
		Sugar	Beets			
		Lbs	Tons	%	No.	%
2196-3: Topcross Hybrids w/ C78 as Tester						
Rival	L1031203, HH103, 8-29-95	10759	35.69	147	80.9	0.4
	Spreckels 941000, 8-21-95	10769	37.92	132	80.9	0.0
	F82-546H3 x RZM R478NB (C78)	10340	36.05	154	81.9	0.0
	F92-790-15CMS x RZM R478NB (C78)	11052	38.33	142	82.2	0.0
R578H51	F92-790-15H26 x RZM R478NB (C78)	10834	37.35	150	80.1	0.0
R578H39	91-762-17CMS x RZM R478NB (C78)	11210	40.95	143	80.4	0.4
R578H52	F92-790-15H39 x RZM R478NB (C78)	11366	40.10	147	82.0	0.0
R578H74	4859-2H50 x RZM R478NB (C78)	10506	37.25	149	81.4	0.0
R578H75	4865-4H50 x RZM R478NB (C78)	10827	38.15	146	80.9	0.0
R578H76	4867-1H50 x RZM R478NB (C78)	10943	37.85	148	80.9	0.0
R578H77	4891-4H50 x RZM R478NB (C78)	11306	39.75	151	81.0	0.0
R578H78	4864-8H50 x RZM R478NB (C78)	10509	37.51	142	80.8	0.0
R578H79	4864-14H50 x RZM R478NB (C78)	10957	38.15	142	81.6	0.0
R578H80	4864-34H50 x RZM R478NB (C78)	11127	40.10	142	80.6	0.0
R581H11	4911-4m,aa x RZM R481-43,-89 (C82)	10533	38.06	127	80.0	0.0
R581H12	4911-4H50 x RZM R481-43,-89 (C82)	10332	37.28	127	79.1	0.5
Mean		10835.7	38.16	143.1	80.9	0.1
LSD (.05)		882.4	2.87	9.9	1.3	0.5
C.V. (%)		8.2	7.59	7.0	1.7	657.3
F value		1.1NS	1.99*	5.2**	2.9**	0.9NS

NOTES: Grown in Block 5 under nonrhizomania conditions. Tip rot caused by Phytophthora reduced stands and caused sprangling within a few entries. F82-546H3 = C562CMS x C546. F92-790-15H26 = C309CMS x C790-15. 790-15H39 = C762-17CMS x C790-15. 4911-4 = C911-4aa. 4911-4H50 = C790-15CMS x C911-4.

# TEST 2396. PERFORMANCE OF POPULATION HYBRIDS, 1996

24 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: September 17, 1996

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	RJAP %	Root Rot %
		Sugar Lbs	Beets Tons				
4454	Comm. hybrid, 4002 (4-28-95)						
US H11	L113401, 11-16-94	10189	35.42	14.38	133	81.0	0.0
Rizor	SES F291, 2-13-96	8788	31.92	13.74	148	81.2	0.0
5911-4H50(Sp)	F92-790-15CMS x RZM 4911-4m	10777	32.48	16.59	145	80.0	0.0
		10583	37.44	14.13	145	80.3	0.0
R578H50	F92-790-15CMS x RZM R478NB	9940	33.85	14.71	147	81.4	0.0
R578H11	4911-4-M(C)aa x RZM R478NB	9942	35.23	14.10	152	81.7	0.3
R578H12	4911-4H50 x RZM R478NB	10408	35.74	14.55	142	81.6	0.0
R578H16	4915-#(C)aa x RZM R478NB	9305	33.19	13.99	131	79.8	0.0
R578H18	4918(Sp)aa x RZM R478NB	10049	34.31	14.64	140	81.3	0.0
R578H19	4918-#(C)aa x RZM R478NB	10169	35.01	14.51	143	81.5	0.0
R578H13	4918H50 x RZM R478NB	10429	36.17	14.43	145	81.3	0.0
R578H59	4859m,aa(C859)x RZM R478NB	9832	33.93	14.52	142	81.5	0.0
R578H65	4865m,aa x RZM R478NB	9342	33.41	13.99	140	80.1	0.0
R578H87	4890m,aa(C890)x RZM R478NB	10171	35.05	14.52	137	81.4	0.8
R578H93	4893aa x RZM R478NB	10104	36.60	13.80	150	79.6	0.0
R578H94	4894aa x RZM R478NB	9801	34.15	14.36	130	81.3	0.0
R581H50	F92-790-15CMS x RZM R481-43,-89	10668	37.50	14.23	139	81.0	0.0
R581H18	RZM 4918aa x RZM R481-43,-89	10191	36.69	13.89	131	78.8	0.0
R581H59	RZM 4859m,aa x RZM R481-43,-89	9736	33.98	14.38	137	80.6	0.0
R581H65	RZM 4865m,aa x RZM R481-43,-89	9162	33.35	13.76	143	80.1	0.0
R581H65NB	RZM 4865NBaa x RZM R481-43,-89	9727	34.03	14.32	145	79.9	0.0
R581H87	RZM 4890m,aa x RZM R481-43,-89	10563	37.72	14.04	150	81.5	0.0
R576-89-18H50	F92-790-15CMS x R476-89-18	10067	34.64	14.50	143	80.2	0.0
R576-89-18H18	RZM 4918aa x R476-89-18	10039	34.31	14.64	140	80.2	0.0
Mean		9999.2	34.84	14.36	141.6	80.7	0.0
LSD (.05)		837.7	2.72	0.46	11.7	2.0	0.5
C.V. (%)		8.5	7.94	3.28	8.4	2.5	1056.6
F value		2.7**	2.60**	11.24**	20**	1.2NS	1.0NS

NOTE: See tests 2196, 1696 (virus yellows), and 4196, 4396, & 6296 (rhizomania).  
4918 = C918. 4918-#(C) = S<sub>1</sub> composite from C918. 4911-4m = C911-4. R478NB = C78. R481-43,-89 = C82.

# TEST 1696. VIRUS YELLOWWS EVALUATION OF EXPERIMENTAL HYBRIDS, SALINAS, CA., 1996

24 entries x 8 reps, RCB (equalized)  
1-row plots, 21 ft. long

Planted: April 15, 1996  
Harvested: October 1, 1996  
BYV/BWV Inoc.: June 4, 1996\*

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %	Virus Yellows %
		Sugar Lbs.	Beets Tons				
SS-781R	941000 (8-21-95)	6585	25.40	147	12.95	77.9	5.3
Rival	HH103, L1031203 (8-29-95)	5958	21.99	136	13.59	78.9	6.0
4006R	Betaseed (2-8-96)	4557	16.07	102	14.13	78.4	6.1
6770	High 8S, susc.check (2-8-96)	6045	21.25	144	14.21	80.2	6.0
4454	Comm.check, 4454.4002 (4-28-95)	8148	29.83	143	13.66	78.2	5.4
R581H50	F92-790-15CMS x RZM R481-43, -89	8154	30.50	145	13.39	79.5	4.3
R581H12	4911-4H50 x RZM R481-43, -89	7578	28.40	130	13.34	78.2	4.4
R581H11	4911-4m,aa x RZM R481-43, -89	7882	29.50	133	13.33	78.3	4.0
R576-89-18H50 (Sp)	F92-790-15CMS x R476-89-18	8744	31.46	141	13.88	80.1	4.6
R576-89-18H9	4911-4-#M(C)aa x R476-89-18	8474	30.58	120	13.87	78.3	4.1
5911-4H50	F92-790-15CMS x RZM 4911-4m	8421	30.65	148	13.75	77.8	4.4
R578H50	F92-790-15CMS x RZM R478NB	7183	26.55	142	13.53	79.2	5.0
R578H12	4911-4H50 x RZM R478NB	7502	26.70	141	14.06	80.0	4.6
R578H11	4911-4#M(C)aa x RZM R478NB	7490	27.75	134	13.50	78.6	4.3
5913-70H50	F92-790-15CMS x RZM 3913-70	9260	34.55	148	13.41	78.1	3.8
5913-71H50	F92-790-15CMS x RZM 4913-71	7911	30.85	137	12.81	77.8	4.2
R576-43-14H50	F92-790-15CMS x RZM R476-43-14	8011	29.21	136	13.71	80.1	4.4
R576-43-15H50	F92-790-15CMS x RZM R476-43-15	8186	28.57	136	14.32	80.7	4.2
R576-89-5H50	F92-790-15CMS x RZM R476-89-5	9405	32.55	147	14.41	79.8	3.7
R578H8	F82-546H3 x RZM R478NB	6581	25.20	142	13.10	79.0	5.3
R578H52	F92-790-15H39 x RZM R478NB	7582	28.42	137	13.34	79.8	5.3
R540H50	F92-790-15CMS x R40(C)	7627	29.11	136	13.11	78.2	4.6
5921H50	F92-790-15CMS x RZM R21(C)	7828	30.16	139	12.96	75.6	4.9
R522H50	F92-790-15CMS x RZM R22(C)	8169	30.40	148	13.41	78.3	4.7
Mean		7636.8	28.15	138.0	13.57	78.8	4.7
LSD (.05)		809.6	2.87	13.7	0.40	1.1	0.3
C.V. (%)		10.8	10.34	10.1	3.01	1.5	6.3
F value		13.9**	14.98**	4.2**	9.32**	7.8**	42.8**

\* Inoculated with virus yellows complex that included BYV, BWV, and the more recently identified luteovirus identified in CA, TX, CO, NE. Virus yellows scored 5 times on a scale of 0 to 9 where 0 = green and 9 = 100% yellowed canopy. A seedling tip rot diagnosed as being caused by Phytophthora caused differential seedling loss and sprangling.

NOTES: See tests 2196 & 2396 (nondiseased) and 4196, 4396, & 6296 (rhizomania).



TEST 4196. RHIZOMANIA EVALUATION OF TESTCROSS AND POPULATION HYBRIDS, BLOCK 2S,  
SALINAS, CA., 1996

32 entries x 8 replications, RCB (equalized)  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 16, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Root Rot %	Powdery Mildew		RJAP %
		Sugar Lbs	Beets Tons				Score	Score	
4006R Rizor SS-781R US H11	2-8-96	8719	29.39	158	14.88	0.0	7.1	80.6	
	LF291, 2-13-96	9348	29.73	181	15.70	0.4	7.4	79.1	
	941000, 2-28-95	8082	30.24	173	13.39	0.0	7.4	80.4	
	L113401, 11-16-94	5285	22.12	183	11.95	0.0	8.4	81.7	
R578H8	F82-546H3 x RZM R478NB(C78)	7787	28.02	190	13.88	0.0	7.6	80.3	
R578H50	F92-790-15CMS x RZM R478NB(C78)	9298	32.91	194	14.14	0.0	6.8	82.5	
R578H12	4911-4H50 x RZM R478NB(C78)	9272	32.68	184	14.21	0.4	6.5	81.5	
R578H11	4911-4-#M(C)aa x RZM R478NB(C78)	9030	32.81	183	13.76	0.0	6.6	80.5	
R578H13	4918H50 x RZM R478NB(C78)	9381	33.10	176	14.18	0.0	6.3	82.1	
R578H19	4918-#(C)aa x RZM R478NB(C78)	9540	33.27	186	14.34	0.3	6.3	80.6	
R522H18	4918aa x RZM R522(C)(C51)	9970	35.41	184	14.06	0.7	7.1	78.1	
R581H50	F92-790-15CMS x RZM R481-43,-89(C82)	8835	31.99	183	13.80	0.0	6.4	82.1	
R581H12	4911-4H50 x RZM R481-43,-89(C82)	9432	33.45	164	14.07	0.0	6.5	80.0	
R581H11	4911-4m,aa x RZM R481-43,-89(C82)	9909	35.34	186	14.05	0.0	6.4	79.9	
R581H59	RZM 4859m,aa x RZM R481-43,-89(C82)	8149	29.32	168	13.88	0.0	7.1	80.4	
R581H87	RZM 4890m,aa x RZM R481-43,-89(C82)	9902	36.60	179	13.51	0.0	6.6	80.8	
R581H65	RZM 4865m,aa x RZM R481-43,-89(C82)	8949	33.92	166	13.19	0.0	6.8	80.9	
R581H65NB	RZM 4865NBaa x RZM R481-43,-89(C82)	8320	30.80	181	13.50	0.0	7.3	77.3	
R578H74	4859-2H50 x RZM R478NB(C78)	8480	31.11	188	13.68	0.0	6.9	81.1	
R578H75	4865-4H50 x RZM R478NB(C78)	9523	33.88	178	14.07	0.0	7.0	80.3	
R578H76	4867-1H50 x RZM R478NB(C78)	9182	32.69	172	14.01	0.0	6.6	80.5	
R578H77	4891-4H50 x RZM R478NB(C78)	9023	32.76	180	13.80	0.4	6.5	80.3	
R578H78	4864-8H50 x RZM R478NB(C78)	8197	30.57	179	13.41	0.0	7.1	80.6	
R578H79	4864-14H50 x RZM R478NB(C78)	9704	33.80	181	14.35	0.0	7.1	81.3	
R578H80	4864-34H50 x RZM R478NB(C78)	9081	33.27	188	13.65	0.0	7.1	82.0	
R578H59	4859m,aa x RZM R478NB(C78)	9304	32.16	169	14.46	0.0	7.6	80.1	
R578H65	4865m,aa x RZM R478NB(C78)	8656	31.10	185	13.93	0.0	7.8	81.1	
R578H87	4890m,aa x RZM R478NB(C78)	8987	32.87	189	13.64	0.4	6.9	80.8	

TEST 4196. RHIZOMANIA EVALUATION OF TESTCROSS AND POPULATION HYBRIDS, BLOCK 2S,  
SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	No.	Root Rot %	Powdery		RJAP %
		Sugar	Beets					Mildew	Score	
		<u>Lbs</u>	<u>Tons</u>							
4893aa	x RZM R478NB(C78)	9538	34.27	183	13.94	183	0.4	7.1	80.4	
4894aa	x RZM R478NB(C78)	9684	34.73	175	13.96	175	0.0	7.1	81.3	
4911-4-#M(C)aa x	R476-89-18	8907	31.41	158	14.18	158	0.0	6.5	80.5	
HH103, L1031203, 8-29-95		9767	32.27	187	15.13	187	0.7	7.6	81.2	
Mean		8976.2	32.13	179.0	13.96	179.0	0.1	7.0	80.6	
LSD (.05)		847.3	2.80	14.8	0.53	14.8	0.6	0.5	2.2	
C.V. (%)		9.6	8.84	8.4	3.85	8.4	557.2	7.4	2.7	
F value		8.4**	6.97**	2.9**	10.81**	2.9**	0.9NS	7.4**	1.9*	

NOTE: Test 4196 was under moderate rhizomania. See tests 2196 & 2396 (nondiseased), 1696 (virus yellows), 4396 (mild rhizomania), and 6296 (severe rhizomania). R476-89-18 = C76-89-18. F82-546H3 = C562CMS x C546. 4911-4H50 = C790-15CMS x C911-4. 4911-4-#M(C) = S<sub>1</sub> composite from C911-4M. 4918H50 = C790-15CMS x C918. 4918 = C918. 4918-#(C) = S<sub>1</sub> composite from C918. 4859 = C859. 4890 = C890.

TEST 4396. RHIZOMANIA EVALUATION OF HYBRIDS, BLOCK 2S, SALINAS, CA., 1996

32 entries x 8 replications, RCB (equalized)  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 7, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Beets/ 100' No.	RJAP %	Powdery Mildew	
		Sugar Lbs	Beets Tons					Score	Score
SS-694R	11-13-95	7800	28.36	179	13.74	179	78.0	6.4	
4006R	2-8-96	8885	28.44	188	15.64	188	80.4	6.0	
Rival	HH103, 8-29-95	8586	28.92	188	14.84	188	78.2	6.3	
Rizor	Lot F291, 2-13-96	9305	29.30	191	15.89	191	78.2	6.5	
US H11	L113401, 11-16-94	5154	20.42	188	12.63	188	79.1	6.8	
SS-NB7R	L950840, 11-13-95	7943	27.59	166	14.37	166	78.7	6.1	
R578H50	F92-790-15CMS x RZM R478NB (C78)	8387	29.72	183	14.14	183	79.1	6.3	
R522H50	F92-790-15CMS x RZM R522(C) (C51)	9022	32.53	181	13.87	181	77.0	6.1	
R480-45H50	F92-790-15CMS x R280-45 (C80-45)	8288	28.88	184	14.35	184	79.1	6.1	
R579H50	F92-790-15CMS x RZM R479 (C79-1,Rz)	8328	29.56	181	14.07	181	79.4	6.3	
R535H50	F92-790-15CMS x RZM R435 (C79-7,SES)	8486	28.98	181	14.63	181	79.0	6.4	
R536H50	F92-790-15CMS x RZM R436 (C79-8,R22)	8011	29.03	187	13.78	187	77.8	6.4	
R540H50	F92-790-15CMS x RZM R40(C) (C79-#s)	7587	28.14	184	13.46	184	78.3	6.4	
5921H50	F92-790-15CMS x RZM R21(C)	7723	27.83	190	13.88	190	78.3	5.9	
Z430H50	F92-790-15CMS x RZM Z330 (25% Polish)	9360	31.82	181	14.73	181	79.2	6.0	
5915% H50	F92-790-15CMS x RZM-#S 3915	9014	31.02	187	14.52	187	78.8	5.8	
R581H52	F92-790-15H39 x RZM R481-43,-89 (C82)	9326	34.42	180	13.57	180	78.9	5.8	
R581H50	F92-790-15CMS x RZM R481-43,-89 (C82)	8403	30.14	173	13.93	173	79.4	6.3	
R476-43-14H50	F92-790-15CMS x RZM R376-43-14 (C76-43-14)	8352	29.43	196	14.19	196	81.4	5.6	
R476-43-15H50	F92-790-15CMS x RZM R376-43-15 (C76-43-15)	7832	28.54	186	13.71	186	79.7	5.9	
R576-89-5H50	F92-790-15CMS x RZM R476-89-5 (C76-89-5)	9055	29.72	192	15.23	192	80.6	6.1	
R576-89-18H50	F92-790-15CMS x RZM R476-89-18 (C76-89-18)	8227	28.82	182	14.27	182	79.9	6.3	
R543R2H50	F92-790-15CMS x RZM R443	8838	30.78	183	14.38	183	78.7	6.0	
R544R2H50	F92-790-15CMS x RZM R444	8227	29.14	186	14.12	186	78.8	6.1	
5911-4H50(SP)	F92-790-15CMS x RZM 4911-4m (C911-4)	8742	30.30	182	14.42	182	79.1	6.3	
5913-70H50	F92-790-15CMS x RZM 3913-70 (C913-70)	9905	33.75	189	14.69	189	78.9	5.6	
R578H50-#	4790-15-#(C)CMS x RZM R478NB (C78)	9195	32.97	189	13.93	189	79.1	5.8	
R578H50-21	4790-15-21CMS x RZM R478NB (C78)	8552	30.82	190	13.89	190	79.9	5.6	

TEST 4396. RHIZOMANIA EVALUATION OF HYBRIDS, BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	No.	RJAP %	Powdery	
		Sugar	Beets					Mildew	Score
		Lbs	Tons						
R578H50-23	4790-15-23CMS x RZM R478NB (C78)	8659	30.82	175	14.05	175	79.1	6.3	
R578H18	4918aa x RZM R478NB (C918aa x C78)	8600	29.48	172	14.58	172	79.2	6.0	
R576-89-18H18	RZM 4918aa x R476-89-18 (C76-89-18)	8335	28.12	179	14.83	179	79.2	5.6	
R581H18	RZM 4918aa x RZM R481-43,-89 (C82)	9025	31.96	161	14.11	161	78.7	5.3	
Mean		8473.5	29.68	182.9	14.26	182.9	79.0	6.1	
LSD (.05)		826.6	2.71	15.4	0.39	15.4	1.0	0.7	
C.V. (%)		9.9	9.25	8.5	2.74	8.5	1.3	11.5	
F value		7.5**	6.17**	1.8NS	20.75**	1.8NS	5.3**	1.7*	

NOTE: This test was adjacent to CBGA coded RZM 4096-2 and had mild rhizomania.

See tests 2196 & 2396 (nondiseased), 1696 (virus yellows), 4196 (moderate rhizomania), and 6296 (severe rhizomania).

F92-790H39 = C762-17CMS x C790-15. 4790-15-#, -21,-23 are selections from C790-15. 4918 = C918.

TEST 6296. RHIZOMANIA EVALUATION HYBRIDS, FIELD C, SALINAS, CA., 1996

16 entries x 8 replications, RCB (equalized)  
1-row plots, 21 ft. long

Planted: June 3, 1996  
Harvested: November 5, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	RJAP %
		Sugar Lbs	Beets Tons			
Rival	HH103, 8-29-95 Holly	4282	16.31	182	13.11	78.5
Rizor	F291, 2-13-96 SES	4554	15.73	177	14.44	77.3
US H11	L113401, 11-16-94	1385	8.18	185	8.54	71.6
SS-781R	941000, 2-28-95 Spreckels	4204	17.70	172	11.88	77.9
SS-NB7R	Spreckels, 11-13-95	4198	17.29	160	12.19	76.6
4006R	2-8-96 Betaseed	4550	16.41	175	13.86	78.4
R522H50	F92-790-15CMS x RZM R522(C) (C51)	4383	18.16	158	12.06	76.1
5921H50	F92-790-15CMS x RZM R21(C)	4260	17.43	183	12.23	75.7
R578H50	F92-790-15CMS x RZM R478NB (C78)	4058	16.65	162	12.18	77.7
R540H50	F92-790-15CMS x RZM R40(C)	3827	16.29	170	11.75	76.8
R581H50	F92-790-15CMS x RZM R481-43,-89 (C82)	5042	20.05	159	12.55	78.5
R576-89-18H50 (Sp)	F92-790-15CMS x R476-89-18 (C76-89-18)	4264	17.51	181	12.16	78.3
5911-4H50	F92-790-15CMS x RZM 4911-4m (C911-4)	4459	18.10	168	12.36	77.5
5913-70H50	F92-790-15CMS x RZM 3913-70 (C913-70)	5541	21.77	82 <sup>1</sup>	12.73	77.8
R576-89-18H18	RZM 4918aa x R476-89-18 (C76-89-18)	5638	21.32	171	13.24	79.0
R578H18	4918aa (C918) x RZM R478NB (C78)	4350	16.97	172	12.82	77.5
Mean		4312.1	17.24	166.1	12.38	77.19
LSD (.05)		683.7	2.62	17.8	0.49	2.10
C.V. (%)		16.0	15.37	10.8	3.99	2.74
F value		14.4**	10.20**	14.3**	51.80**	5.48**

<sup>1</sup> Low stand count due to very low seeding rate. Yield adjusted for missing feet.

NOTE: See tests 2196 & 2396 (nondiseased), 1696 (virus yellows), 4196 (moderate rhizomania), and 4396 (mild rhizomania).

TEST 3796. WESTERN SUGAR RHIZOMANIA TEST, BLOCK 2S, SALINAS, CA., 1996

32 entries x 8 replications, RCB (combined 4096-1 & 4096-2)  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 22 & 24, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Powdery Mildew Score	RJAP %	Resistance	
		Sugar Lbs.	Beets Tons					DI	%R
WS entries and checks									
H93251	Spreckels	8304	27.94	164	14.84	7.3	80.6	3.6	71.6
HM 1633	Hilleshog	7849	29.92	172	13.03	7.6	80.5	3.6	65.1
B4006R	Betaseed	8813	28.45	161	15.41	7.0	80.2	3.4	79.8
Rhizosen	Holly Hybrids	8597	29.74	169	14.42	6.6	78.2	3.4	76.9
H93694	Spreckels	7902	29.68	170	13.27	7.4	79.6	3.4	80.6
ACH9613	Amer. Crystal	7739	29.69	168	13.00	7.3	80.2	4.0	54.3
4J0197	Betaseed	8749	27.23	156	16.06	7.3	81.8	3.3	80.0
95HX326	Holly Hybrids	7221	24.83	136	14.50	6.9	80.7	3.7	68.5
H92505	Spreckels	7674	27.21	154	14.06	6.9	81.5	3.8	63.2
M9372	Amer. Crystal (Maribo)	7872	26.69	184	14.76	7.4	79.3	3.4	82.3
HM 1632	Hilleshog	8295	30.16	174	13.76	6.8	80.2	3.6	67.7
H93861	Spreckels	6914	24.78	178	13.97	6.9	79.3	3.5	72.1
Mohohikari	Check (Seedex)	6008	22.28	167	13.48	6.9	82.4	4.7	30.3
HH50	Check (Holly)	5107	21.17	185	11.96	7.1	80.2	3.9	57.4
Kojak	Check (Seedex)	7896	29.07	197	13.57	6.3	81.4	3.3	84.3
US H11	L113401, 11-16-94	4184	18.07	176	11.28	8.0	78.9	4.8	26.2
Idaho Seed Committee (Gallian)									
SS943203	Spreckels	7439	26.84	164	13.87	7.0	80.9	3.6	74.1
SS93805	Spreckels	7638	28.76	178	13.24	7.3	80.4	3.5	74.1
SS93424	Spreckels	8194	29.56	168	13.84	7.1	80.0	3.3	83.9
H944205	Check (Spreckels, 4-96)	7448	28.44	173	13.06	7.4	79.2	3.1	88.1

TEST 3796. WESTERN SUGAR RHIZOMANIA TEST, BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Sucrose %	Beets/ 100' No.	Powdery Mildew Score	RJAP %	RZM	
		Sugar Lbs	Beets Tons					Resistance DI	%R
Betaseed entries									
BTS-1	Betaseed, 4-96	8003	28.84	13.88	141	7.5	78.6	3.6	70.7
BTS-2	Betaseed, 4-96	8327	31.04	13.36	178	6.5	80.9	3.2	83.9
BTS-3	Betaseed, 4-96	8883	32.46	13.63	170	6.8	81.1	3.3	82.3
BTS-4	Betaseed, 4-96	7678	28.16	13.56	171	8.4	79.3	3.2	89.6
BTS-5	Betaseed, 4-96	7867	26.07	15.06	171	8.0	80.2	3.0	92.7
USDA entries									
Rizor	Check (F291, 2-13-96) (SES)	7932	25.23	15.70	179	7.6	79.0	3.0	93.3
4454	Check (4002, 4-28-95) (BTS)	6005	22.58	13.21	186	6.3	80.1	4.4	35.0
6770	Check (%S check, 2-8-96) (KWS)	5416	19.91	13.46	168	7.0	80.8	4.4	35.1
Rival	HH103, L1031203, 8-29-95	8214	28.62	14.31	183	7.6	79.9	2.9	93.4
R578H50	F92-790-15CMS x RZM R478NB	7928	28.77	13.71	178	6.3	81.3	3.4	79.6
R522H50	F92-790-15CMS x RZM R522(C)	7990	30.59	13.01	170	7.0	78.3	2.8	97.3
5921H50	F92-790-15CMS x RZM R21(C)	7371	27.90	13.22	163	6.6	79.1	3.2	85.0
Mean		7545.6	27.21	13.80	170.4	7.1	80.1	3.5	72.5
LSD (.05)		967.3	3.23	0.57	19.5	0.6	1.9	0.5	18.9
C.V. (%)		13.0	12.05	4.20	11.6	7.9	2.4	9.8	18.6
F value		9.9**	8.36**	23.16**	3.1**	6.6**	2.3**	7.8**	7.8**

NOTES: Rhizomania scored on 4 replications (3796-1). Rated on a scale of 0 to 9 where 0 = immune and 9 = dead. Most roots were rated 1,3,5, or 7 where 0-3 = resistant and 4-9 = susceptible.

Powdery mildew controlled August-September with Bayleton, then mildew developed late. Powdery mildew scored 10-07-96 on a scale of 0 to 9. Mildew probably had little affect on yield. Other foliar diseases were minimal. Other root diseases may have influenced yield: prior to thinning, a warm rain caused a tip rot (diagnosed as Phytophthora which differentially reduced stands (particularly under severe rhizomania) and/or left plants without a tap root and fangy. Cyst nematode were evident at harvest and caused mild rhizomania-like symptoms.

Test 3796-1 was a plant-back to an area with sugarbeet in 1995. Test 3796-2 was not in sugarbeet in 1995. Both areas were inoculated with rhizomania in 1994. These areas were in the same plot field and otherwise had identical cultural practices.

RJAP = raw juice apparent purity.

For USDA experimental hybrids: R478NB = C78; R522(C) = C51.

TEST 3796-1. WESTERN SUGAR RHIZOMANIA TEST (SEVERE RHIZOMANIA), BLOCK 2S, SALINAS, CA., 1996

32 entries x 4 replications, RCB (hand harvested & scored)  
1-row plots, 20 ft. long (2 sugar samples, total plot weighed)

Planted: May 1, 1996  
Harvested: October 24, 1996

Variety	Description	Acre Yield		Beets/ 100'	Powdery Mildew	RJAP %	RZM	
		Sugar Lbs.	Beets Tons				Sucrose %	Resistance <u>DI</u> <u>%R</u>
<u>WS entries and checks</u>								
H93251	Spreckels	7174	24.62	166	7.3	79.5	3.6	71.6
HM 1633	Hilleshog	6512	25.56	178	7.5	79.0	3.6	65.1
B4006R	Betaseed	7117	23.91	148	7.0	79.0	3.4	79.8
RRhizosen	Holly Hybrids	7363	26.20	180	6.5	77.3	3.4	76.9
H93694	Spreckels	6765	26.91	179	7.3	79.0	3.4	80.6
ACH9613	Amer. Crystal	6388	25.26	163	7.3	79.3	4.0	54.3
4J0197	Betaseed	7785	24.15	146	6.8	81.6	3.3	80.0
95HX326	Holly Hybrids	6300	22.03	125	6.8	80.2	3.7	68.5
H92505	Spreckels	6455	23.44	149	6.8	81.0	3.8	63.2
M9372	Amer. Crystal (Maribo)	6891	23.15	176	7.3	78.5	3.4	82.3
HM 1632	Hilleshog	7317	26.61	161	7.0	79.7	3.6	67.7
H93861	Spreckels	6045	21.62	180	6.8	78.5	3.5	72.1
Mohohikari	Check (Seedex)	4667	17.51	169	6.8	81.3	4.7	30.3
HH50	Check (Holly)	3947	17.04	186	7.0	77.9	3.9	57.4
Kojak	Check (Seedex)	7216	27.38	200	6.0	80.8	3.3	84.3
US H11	L113401, 11-16-94	2716	13.45	174	8.0	76.9	4.8	26.2
<u>Idaho Seed Committee (Gallian)</u>								
SS943203	Spreckels	6110	22.50	148	6.8	81.2	3.6	74.1
SS93805	Spreckels	6415	24.56	180	7.3	79.0	3.5	74.1
SS93424	Spreckels	6603	24.26	168	7.0	79.3	3.3	83.9
H944205	Check (Spreckels, 4-96)	6095	23.91	171	7.3	78.2	3.1	88.1



TEST 3796-1. WESTERN SUGAR RHIZOMANIA TEST (SEVERE RHIZOMANIA), BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Powdery Mildew Score	RJAP %	RZM	
		Sugar Lbs	Beets Tons					Resistance DI	Resistance %R
Betaseed entries									
BTS-1	Betaseed, 4-96	7004	26.03	136	13.52	7.8	78.0	3.6	70.7
BTS-2	Betaseed, 4-96	6571	25.32	171	12.98	6.8	79.6	3.2	83.9
BTS-3	Betaseed, 4-96	7729	28.73	165	13.49	6.8	81.1	3.3	82.3
BTS-4	Betaseed, 4-96	6578	25.38	169	12.94	8.5	77.2	3.2	89.6
BTS-5	Betaseed, 4-96	6702	22.68	161	14.79	8.0	79.4	3.0	92.7
USDA entries									
Rizor	Check (F291,2-13-96) (SES)	7720	24.20	178	15.95	7.5	78.6	3.0	93.3
4454	Check (4002,4-28-95) (BTS)	4689	18.27	189	12.77	5.8	78.4	4.4	35.0
6770	Check (%S check,2-8-96) (KWS)	4073	15.57	176	13.02	6.8	79.6	4.4	35.1
Rival	HH103, L1031203, 8-29-95	7295	25.73	183	14.17	7.5	79.2	2.9	93.4
R578H50	F92-790-15CMS x RZM R478NB	6649	25.09	169	13.24	5.8	79.6	3.4	79.6
R522H50	F92-790-15CMS x RZM R522(C)	6804	26.73	173	12.70	6.5	77.6	2.8	97.3
5921H50	F92-790-15CMS x RZM R21(C)	7088	26.65	160	13.29	6.5	79.5	3.2	85.0
Mean		6399.6	23.58	167.9	13.51	7.0	79.2	3.5	72.5
LSD (.05)		1302.4	4.54	29.3	0.79	0.9	2.6	0.5	18.9
C.V. (%)		14.5	13.72	12.4	4.18	8.8	2.3	9.8	18.6
F value		6.4**	4.93**	2.3**	16.95**	3.9**	1.8*	7.8**	7.8*

NOTES: Rhizomania scored on 4 replications (3796-1). Rated on a scale of 0 to 9 where 0 = immune and 9 = dead. Most roots were rated 1,3,5, or 7 where 0-3 = resistant and 4-9 = susceptible.

Powdery mildew controlled August-September with Bayleton, then mildew developed late. Powdery mildew scored 10-07-96 on a scale of 0 to 9. Mildew probably had little affect on yield. Other foliar diseases were minimal. Other root diseases may have influenced yield: prior to thinning, a warm rain caused a tip rot (diagnosed as Phytophthora which differentially reduced stands (particularly under severe rhizomania) and/or left plants without a tap root and fangy. Cyst nematode were evident at harvest and caused mild rhizomania-like symptoms.

Test 3796-1 was a plant-back to an area with sugarbeet in 1995. Test 3796-2 was not in sugarbeet in 1995. Both areas were inoculated with rhizomania in 1994. These areas were in the same plot field and otherwise had identical cultural practices.

RJAP = raw juice apparent purity.

For USDA experimental hybrids: R478NB = C78; R522(C) = C51.

TEST 3796-2. WESTERN SUGAR RHIZOMANIA TEST (MILD RHIZOMANIA), BLOCK 2S, SALINAS, CA., 1996

32 entries x 4 replications, RCB (machine harvested)  
1-row plots, 20 ft. long (2 sugar subsamples/plot)

Planted: May 1, 1996  
Harvested: October 22, 1996

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Beets/ 100'	Powdery Mildew		RJAP %
		Sugar	Beets				Score	No.	
		Lbs	Tons						
WS entries and checks									
H93251	Spreckels	9433	31.26	163	15.10	163	7.3		81.6
HM 1633	Hilleshog	9187	34.28	166	13.36	166	7.8		81.9
B4006R	Betaseed	10509	32.99	175	15.93	175	7.0		81.4
RRhizosen	Holly Hybrids	9831	33.29	158	14.77	158	6.8		79.1
H93694	Spreckels	9039	32.45	161	13.95	161	7.5		80.1
ACH9613	Amer. Crystal	9089	34.13	173	13.34	173	7.3		81.0
4J0197	Betaseed	9713	30.31	166	16.02	166	7.8		81.9
95HX326	Holly Hybrids	8142	27.63	146	14.74	146	7.0		81.2
H92505	Spreckels	8893	30.98	160	14.36	160	7.0		82.1
M9372	Amer. Crystal (Maribo)	8853	30.24	191	14.61	191	7.5		80.0
HM 1632	Hilleshog	9273	33.71	186	13.75	186	6.5		80.7
H93861	Spreckels	7783	27.93	176	13.94	176	7.0		80.1
Mohohikari	Check (Seedex)	7349	27.06	165	13.59	165	7.0		83.5
HH50	Check (Holly)	6267	25.31	184	12.44	184	7.3		82.4
Kojak	Check (Seedex)	8575	30.77	194	13.94	194	6.5		82.0
US H11	L113401, 11-16-94	5651	22.68	179	12.45	179	8.0		80.8
Idaho Seed Committee (Gallian)									
SS943203	Spreckels	8767	31.19	180	14.07	180	7.3		80.7
SS93805	Spreckels	8861	32.96	176	13.44	176	7.3		81.9
SS93424	Spreckels	9785	34.86	169	14.04	169	7.3		80.6
H944205	Check (Spreckels, 4-96)	8800	32.97	175	13.38	175	7.5		80.2

TEST 3796-2. WESTERN SUGAR RHIZOMANIA TEST (MILD RHIZOMANIA), BLOCK 2S, SALINAS, CA., 1996

(cont.)

Variety	Description	Acre Yield		Beets/ 100'	Sucrose %	Powdery Mildew		RJAP %
		Sugar	Beets			No.	Score	
		Lbs	Tons					
<u>Betaseed entries</u>								
BTS-1	Betaseed, 4-96	9002	31.65	146	14.24	7.3	79.3	
BTS-2	Betaseed, 4-96	10084	36.75	184	13.74	6.3	82.3	
BTS-3	Betaseed, 4-96	10038	36.20	175	13.77	6.8	81.0	
BTS-4	Betaseed, 4-96	8778	30.94	173	14.19	8.3	81.5	
BTS-5	Betaseed, 4-96	9032	29.47	181	15.34	8.0	81.0	
<u>USDA entries</u>								
Rizor	Check (F291, 2-13-96) (SES)	8143	26.25	181	15.45	7.8	79.3	
4454	Check (4002, 4-28-95) (BTS)	7322	26.88	184	13.64	6.8	81.7	
6770	Check (%S check, 2-8-96) (KWS)	6758	24.26	160	13.89	7.3	82.0	
Rival	HH103, L1031203, 8-29-95	9132	31.50	184	14.45	7.8	80.6	
R578H50	F92-790-15CMS x RZM R478NB	9207	32.44	186	14.19	6.8	82.9	
R522H50	F92-790-15CMS x RZM R522(C)	9177	34.44	168	13.32	7.5	79.0	
5921H50	F92-790-15CMS x RZM R21(C)	7655	29.16	166	13.15	6.8	78.7	
Mean		8691.6	30.84	172.8	14.08	7.3	81.0	
LSD (.05)		1469.5	4.79	26.5	0.73	0.7	2.9	
C.V. (%)		12.0	11.06	10.9	3.69	6.9	2.5	
F value		4.5**	4.05**	1.6NS	10.87**	3.7**	1.4NS	

NOTES: Rhizomania scored on 4 replications (3796-1). Rated on a scale of 0 to 9 where 0 = immune and 9 = dead. Most roots were rated 1,3,5, or 7 where 0-3 = resistant and 4-9 = susceptible.

Powdery mildew controlled August-September with Bayleton, then mildew developed late. Powdery mildew scored 10-07-96 on a scale of 0 to 9. Mildew probably had little affect on yield. Other foliar diseases were minimal. Other root diseases may have influenced yield: prior to thinning, a warm rain caused a tip rot (diagnosed as Phytophthora which differentially reduced stands (particularly under severe rhizomania) and/or left plants without a tap root and fangy. Cyst nematode were evident at harvest and caused mild rhizomania-like symptoms.

Test 3796-1 was a plant-back to an area with sugarbeet in 1995. Test 3796-2 was not in sugarbeet in 1995. Both areas were inoculated with rhizomania in 1994. These areas were in the same plot field and otherwise had identical cultural practices.

RJAP = raw juice apparent purity.

For USDA experimental hybrids: R478NB = C78; R522(C) = C51.

TEST 4096. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1996

64 entries x 8 replications, RCB (combined 4096-1 & 4096-2)  
1-row plots, 20 ft. long

Planted: May 1, 1996  
Harvested: October 21, 1996  
November 1, 1996

Code No.	Variety	Source	Acre Yield		Beets/ 100'	Sucrose %	Powdery Mildew Score	RJAP %	Resistance	
			Sugar Lbs	Beets Tons					DI	%R
SR- 1	4KJ0169	Betaseed	9597	33.19	190	14.48	7.8	81.7	3.0	90.4
SR- 2	3BG6212	Betaseed	9430	29.31	179	16.15	7.4	80.9	3.3	73.7
SR- 3	96HX15	Holly	6762	23.90	193	14.19	7.5	80.8	3.6	57.8
SR- 4	3BG6170	Betaseed	8391	28.65	165	14.67	6.3	80.4	3.4	76.4
SR- 5	H92376	Spreckels	8290	29.86	192	13.88	7.9	80.1	3.1	85.0
SR- 6	HM 3056	Hilleshog	7707	26.28	184	14.62	7.6	80.2	3.4	74.1
SR- 7	Rhizosen CT	Holly	6875	24.99	198	13.76	7.0	81.7	3.7	56.0
SR- 8	H93747	Spreckels	7589	27.20	184	13.89	7.1	80.5	3.4	76.1
SR- 9	Beta 4035R	Betaseed	8933	30.51	185	14.66	6.4	80.8	2.9	91.1
SR-10	2J5324	Betaseed	7775	26.39	154	14.80	7.4	80.3	3.6	69.6
SR-11	95HX26	Holly	6044	21.91	191	13.76	8.0	82.4	3.7	58.9
SR-12	5CG7542	Betaseed	9939	35.78	151	13.86	6.4	82.0	3.0	86.2
SR-13	5CG7540	Betaseed	10101	36.09	183	14.00	6.6	81.1	2.7	97.9
SR-14	H92338	Spreckels	7087	24.92	184	14.27	7.3	80.3	3.5	73.4
SR-15	SS-NB7R	Spreckels	7901	27.47	175	14.41	7.4	81.2	3.0	91.7
SR-16	Rival	Holly	8402	27.83	184	15.15	7.6	80.7	2.7	92.8
SR-17	HM 3048	Hilleshog	7444	25.30	193	14.78	7.9	79.7	3.1	79.6
SR-18	3BG6224	Betaseed	9115	28.25	178	16.14	7.0	80.4	3.5	76.2
SR-19	4KJ0164	Betaseed	10576	36.94	190	14.31	6.3	82.7	2.9	96.1
SR-20	3BG6162	Betaseed	9084	32.01	183	14.21	6.6	80.3	3.3	78.0
SR-21	95HX25	Holly	8441	26.92	176	15.74	7.3	80.1	3.2	89.5
SR-22	SS-NB5R	Spreckels	7949	28.47	170	14.01	7.5	79.9	3.3	75.2
SR-23	3KJ5128	Betaseed	10014	33.87	135	14.81	6.6	80.9	2.9	92.7
SR-24	SS-IV3R	Spreckels	8790	31.07	184	14.13	7.0	81.4	3.1	79.6
SR-25	SS-289R	Spreckels	7103	24.48	189	14.52	8.1	81.8	3.5	67.9
SR-26	H93432	Spreckels	7770	26.28	174	14.78	7.3	81.2	3.5	72.5
SR-27	3BG6166	Betaseed	9636	32.53	168	14.81	6.0	81.9	3.4	76.0
SR-28	4581	Betaseed	9258	31.14	173	14.92	6.5	80.6	2.8	93.0
SR-29	HH-97R	Holly	6201	23.18	182	13.42	7.3	81.7	4.2	40.3
SR-30	3BG6226	Betaseed	8343	27.43	190	15.31	8.0	79.7	2.9	97.4
SR-31	4KJ0195	Betaseed	6801	24.09	133	14.19	7.1	80.4	3.4	72.2
SR-32	US H11	Check	4680	19.54	163	11.76	8.5	78.8	4.4	36.6

TEST 4096. CBGA SALINAS CODED RHIZOMANIA TEST, SALINAS, CA., 1996

(cont.)

Code No.	Variety	Source	Acre Yield		Beets/ 100'	Sucrose %	Powdery Mildew Score	RJAP %	RZM Resistance	
			Sugar Lbs	Beets Tons					DI	%R
SR-33	SS-334R	Spreckels	7420	24.97	184	14.86	8.3	81.4	3.2	81.8
SR-34	4776R	Betaseed	10915	34.62	187	15.77	6.6	80.9	2.9	92.6
SR-35	HM3042	Hilleshog	9293	32.74	177	14.25	6.9	81.0	2.9	87.6
SR-36	96HX12	Holly	7052	24.97	180	14.15	7.3	81.8	3.7	64.0
SR-37	H944178	Spreckels	8535	30.67	185	13.92	7.3	80.7	3.1	85.7
SR-38	96HX11	Holly	9159	30.15	181	15.20	7.4	80.6	2.9	92.7
SR-39	3BG6188	Betaseed	9752	32.51	151	15.02	6.3	80.7	3.4	72.3
SR-40	SS-781R	Spreckels	8581	29.90	175	14.36	7.1	80.5	3.0	88.4
SR-41	4CG6596	Betaseed	8456	28.44	134	14.91	6.9	78.8	3.3	71.9
SR-42	95HX24	Holly	9659	31.09	170	15.53	7.8	78.9	3.0	88.4
SR-43	96HX14	Holly	7466	26.02	180	14.38	7.1	81.4	3.5	68.5
SR-44	HM 3057	Hilleshog	8161	27.03	181	15.21	7.4	80.1	3.1	87.1
SR-45	SS-NB2R2	Spreckels	7851	27.43	189	14.35	7.9	81.2	3.1	82.1
SR-46	SS-595R	Spreckels	6563	23.41	177	14.04	7.3	79.2	3.8	59.8
SR-47	4006R	Betaseed	8200	26.35	163	15.55	7.1	81.6	3.7	58.8
SR-48	Rhizoguard	Holly	7264	26.47	182	13.82	7.9	80.8	3.1	75.6
SR-49	SS-293R	Spreckels	6717	24.39	199	13.91	7.1	80.4	3.8	63.2
SR-50	96HX13	Holly	7258	25.35	183	14.36	7.6	81.5	3.4	70.5
SR-51	3BG6156	Betaseed	9800	33.11	184	14.88	6.0	81.1	3.3	82.4
SR-52	2J0152	Betaseed	9870	33.29	118	14.88	7.0	80.8	3.0	90.3
SR-53	HH-101R	Holly	7663	27.83	175	13.77	7.5	81.9	3.4	73.5
SR-54	H92326	Spreckels	8617	31.10	190	13.84	7.0	80.5	3.0	85.9
SR-55	4CG6575	Betaseed	9164	29.77	169	15.41	7.0	81.6	2.8	90.4
SR-56	SS-694R	Spreckels	8037	29.22	173	13.72	7.4	81.6	3.2	82.4
SR-57	HM 3055	Hilleshog	8068	27.34	179	14.77	7.3	81.7	3.5	64.6
SR-58	SS-287R	Spreckels	5956	22.59	189	13.21	7.5	81.2	3.5	73.3
SR-59	SS-IV2R	Spreckels	7968	27.95	182	14.28	7.5	81.2	3.6	65.6
SR-60	3BG6225	Betaseed	8345	27.74	172	15.07	7.1	80.1	3.3	75.4
SR-61	HH-102R	Holly	7835	26.82	179	14.61	7.0	81.4	3.4	74.5
SR-62	Rizor	SES F291	8976	27.37	201	16.42	7.9	79.4	3.0	90.2
SR-63	R578H50	USDA	8492	29.07	186	14.59	6.8	81.0	3.2	80.7
SR-64	US H11	USDA	4904	19.72	191	12.30	8.1	80.5	4.6	28.6
Mean			8187.9	28.21	177.1	14.50	7.2	80.8	3.3	76.9
LSD (.05)			924.3	2.99	17.5	0.53	0.5	1.8	0.4	14.6
C.V. (%)			11.5	10.77	10.1	3.72	6.8	2.3	9.2	13.6
F value			14.8**	12.34**	6.6**	17.90**	10.2**	1.7**	6.1**	7.5**

(cont.)

Code No.	Variety	Source	Acre Yield		Sucrose %	Beets/ 100' No.	Powdery Mildew		RJAP %	RZM Resistance	
			Sugar Lbs	Beets Tons			Score	DI		DI	%R

NOTES: Rhizomania scored on 4 replications (4096-1). Rated on a scale of 0 to 9 where 0 = immune and 9 = dead. Most roots were rated 1,3,5, or 7 where 0-3 = resistant and 4-9 = susceptible.

Powdery mildew controlled August-September with Bayleton, then mildew developed late. Powdery mildew scored 09-30-96 on a scale of 0 to 9. Mildew probably had little affect on yield. Other foliar diseases were minimal. Other root diseases may have influenced yield: prior to thinning, a warm rain caused a tip rot (diagnosed as Phytophthora) which differentially reduced stands (particularly under severe rhizomania) and/or left plants without a tap root and fangy. Cyst nematode were evident at harvest and caused mild rhizomania-like symptoms.

Test 4096-1 was a plant-back to an area with sugarbeet in 1995. Test 4096-2 was not in sugarbeet in 1995. Both areas were inoculated with rhizomania in 1994. These areas were in the same plot field and otherwise had identical cultural practices.

RJAP = raw juice apparent purity.

For USDA entries (entries 62, 63, & 64), R578H50 =C790-15CMS x C78.

TEST 4096-1. CBGA SALINAS CODED RHIZOMANIA (SEVERE) TEST, SALINAS, CA., 1996

64 entries x 4 replications, RCB (hand harvested & scored)  
1-row plots, 20 ft. long (2 sugar samples, total plot weighed)

Planted: May 1, 1996  
Harvested: November 1, 1996

Code No.	Variety	Source	Acre Yield		Sucrose %	Beets/100' No.	Powdery Mildew Score	RJAP %	RZM Resistance	
			Sugar Lbs	Beets Tons					DI	%R
SR- 1	4KJ0169	Betaseed	8353	28.38	14.70	189	7.8	80.8	3.0	90.4
SR- 2	3BG6212	Betaseed	7986	24.25	16.48	179	7.3	81.9	3.3	73.7
SR- 3	96HX15	Holly	5448	18.92	14.40	189	7.5	80.5	3.6	57.8
SR- 4	3BG6170	Betaseed	7595	25.38	14.91	156	6.5	80.8	3.4	76.4
SR- 5	H92376	Spreckels	7378	26.79	13.76	194	8.0	80.5	3.1	85.0
SR- 6	HM 3056	Hilleshog	5985	20.86	14.36	179	7.3	80.3	3.4	74.1
SR- 7	Rhizosen CT	Holly	6155	22.68	13.65	195	7.0	80.7	3.7	56.0
SR- 8	H93747	Spreckels	6080	22.38	13.56	181	7.3	80.0	3.4	76.1
SR- 9	Beta 4035R	Betaseed	7434	25.32	14.70	179	6.5	79.8	2.9	91.1
SR-10	2J5324	Betaseed	7138	23.79	15.07	151	7.5	79.6	3.6	69.6
SR-11	95HX26	Holly	4630	17.04	13.59	189	8.0	82.0	3.7	58.9
SR-12	5CG7542	Betaseed	8330	29.67	13.93	145	6.0	81.8	3.0	86.2
SR-13	5CG7540	Betaseed	10124	35.43	14.30	171	6.3	81.1	2.7	97.9
SR-14	H92338	Spreckels	5928	20.86	14.33	189	7.3	80.0	3.5	73.4
SR-15	SS-NB7R	Spreckels	7119	24.29	14.65	165	7.3	81.2	3.0	91.7
SR-16	Rival	Holly	7789	24.79	15.70	179	7.5	80.5	2.7	92.8
SR-17	HM 3048	Hilleshog	6368	21.21	15.06	188	8.0	80.5	3.1	79.6
SR-18	3BG6224	Betaseed	6837	20.80	16.36	173	7.0	81.4	3.5	76.2
SR-19	4KJ0164	Betaseed	9564	34.08	14.06	198	5.8	82.7	2.9	96.1
SR-20	3BG6162	Betaseed	7472	26.32	14.23	180	6.5	79.6	3.3	78.0
SR-21	95HX25	Holly	6928	21.44	16.16	170	7.0	80.6	3.2	89.5
SR-22	SS-NB5R	Spreckels	6856	24.20	14.21	160	7.5	80.4	3.3	75.2
SR-23	3KJ5128	Betaseed	9029	30.26	14.94	121	7.0	80.8	2.9	92.7
SR-24	SS-IV3R	Spreckels	6955	24.97	13.96	183	7.0	82.1	3.1	79.6
SR-25	SS-289R	Spreckels	6225	21.21	14.68	184	8.0	82.0	3.5	67.9
SR-26	H93432	Spreckels	6542	22.33	14.69	176	7.3	81.2	3.5	72.5
SR-27	3BG6166	Betaseed	8462	28.20	14.98	160	6.0	82.3	3.4	76.0
SR-28	4581	Betaseed	8111	26.97	15.11	173	6.0	81.8	2.8	93.0
SR-29	HH-97R	Holly	5024	18.74	13.47	178	7.0	81.2	4.2	40.3
SR-30	3BG6226	Betaseed	7282	23.15	15.79	191	8.0	80.3	2.9	97.4
SR-31	4KJ0195	Betaseed	6276	22.03	14.39	136	6.8	79.4	3.4	72.2
SR-32	US H11	Check	3246	14.89	10.89	168	8.5	77.3	4.4	36.6

## TEST 4096-1. CBGA SALINAS CODED RHIZOMANIA (SEVERE) TEST, SALINAS, CA., 1996

(cont.)

Code No.	Variety	Source	Acre Yield		Beets/ 100' No.	Powdery Mildew Score	RJAP %	Resistance	
			Sugar Lbs	Beets Tons				DI	RZM %R
SR-33	SS-334R	Spreckels	6209	20.86	178	8.3	80.7	3.2	81.8
SR-34	4776R	Betaseed	9938	31.43	191	6.3	80.9	2.9	92.6
SR-35	HM3042	Hilleshog	8326	29.14	178	6.8	81.8	2.9	87.6
SR-36	96HX12	Holly	6248	21.91	180	7.0	82.0	3.7	64.0
SR-37	H944178	Spreckels	7819	28.26	174	7.3	81.0	3.1	85.7
SR-38	96HX11	Holly	7738	25.44	175	7.5	80.3	2.9	92.7
SR-39	3BG6188	Betaseed	8658	28.20	144	6.3	80.6	3.4	72.3
SR-40	SS-781R	Spreckels	8084	27.67	176	7.3	80.4	3.0	88.4
SR-41	4CG6596	Betaseed	6984	23.26	115	7.0	80.1	3.3	71.9
SR-42	95HX24	Holly	8347	26.91	183	7.8	79.4	3.0	88.4
SR-43	96HX14	Holly	6769	23.26	176	7.0	81.2	3.5	68.5
SR-44	HM 3057	Hilleshog	6901	22.15	168	7.3	80.2	3.1	87.1
SR-45	SS-NB2R2	Spreckels	7336	25.15	191	8.0	81.0	3.1	82.1
SR-46	SS-595R	Spreckels	5323	18.98	170	7.3	78.8	3.8	59.8
SR-47	4006R	Betaseed	6929	21.97	150	7.0	81.0	3.7	58.8
SR-48	Rhizoguard	Holly	6842	23.62	188	7.8	81.9	3.1	75.6
SR-49	SS-293R	Spreckels	5606	19.27	198	6.8	79.2	3.8	63.2
SR-50	96HX13	Holly	6427	22.04	189	7.5	80.9	3.4	70.5
SR-51	3BG6156	Betaseed	8639	28.73	179	6.0	81.0	3.3	82.4
SR-52	2J0152	Betaseed	9268	31.26	103	6.8	81.3	3.0	90.3
SR-53	HH-101R	Holly	6664	24.26	168	7.5	82.6	3.4	73.5
SR-54	H92326	Spreckels	7753	28.08	188	7.0	80.2	3.0	85.9
SR-55	4CG6575	Betaseed	8368	27.20	158	6.8	81.8	2.8	90.4
SR-56	SS-694R	Spreckels	7077	25.79	164	7.5	82.1	3.2	82.4
SR-57	HM 3055	Hilleshog	7328	24.73	169	7.0	81.6	3.5	64.6
SR-58	SS-287R	Spreckels	5373	19.98	189	7.5	82.4	3.5	73.3
SR-59	SS-IV2R	Spreckels	7039	24.50	174	7.5	81.9	3.6	65.6
SR-60	3BG6225	Betaseed	7622	25.03	165	7.0	80.0	3.3	75.4
SR-61	HH-102R	Holly	6919	23.50	181	7.0	81.2	3.4	74.5
SR-62	Rizor	SES F291	7842	23.56	198	7.8	79.7	3.0	90.2
SR-63	R578H50	USDA	7642	26.44	188	6.8	80.7	3.2	80.7
SR-64	US H11	USDA	3574	14.98	191	8.0	78.7	4.6	28.6
Mean			7128.7	24.36	173.4	7.2	80.8	3.3	76.9
LSD (.05)			1231.0	4.19	24.3	0.6	2.5	0.4	14.6
C.V. (%)			12.4	12.33	10.0	6.4	2.2	9.2	13.6
F value			9.0**	7.30**	4.9**	7.0**	1.3NS	6.1**	7.5**



TEST 4096-1. CBGA SALINAS CODED RHIZOMANIA (SEVERE) TEST, SALINAS, CA., 1996

(cont.)

Code No.	Variety	Source	Acre Yield		Sucrose %	Beets/ 100'	Powdery Mildew Score	RJAP %	RZM Resistance	
			Sugar Lbs	Beets Tons					DI	%R

NOTES: Rhizomania scored on 4 replications (4096-1). Rated on a scale of 0 to 9 where 0 = immune and 9 = dead. Most roots were rated 1,3,5, or 7 where 0-3 = resistant and 4-9 = susceptible.

Powdery mildew controlled August-September with Bayleton, then mildew developed late. Powdery mildew scored 09-30-96 on a scale of 0 to 9. Mildew probably had little affect on yield. Other foliar diseases were minimal. Other root diseases may have influenced yield: prior to thinning, a warm rain caused a tip rot (diagnosed as Phytophthora) which differentially reduced stands (particularly under severe rhizomania) and/or left plants without a tap root and fangy. Cyst nematode were evident at harvest and caused mild rhizomania-like symptoms.

Test 4096-1 was a plant-back to an area with sugarbeet in 1995. Test 4096-2 was not in sugarbeet in 1995. Both areas were inoculated with rhizomania in 1994. These areas were in the same plot field and otherwise had identical cultural practices.

RJAP = raw juice apparent purity.

For USDA entries (entries 62, 63, & 64), R578H50 =C790-15CMS x C78.

TEST 4096-2. CBGA SALINAS CODED RHIZOMANIA (MILD) TEST, SALINAS, CA., 1996

64 entries x 4 replications, RCB (machine harvested)  
1-row plots, 20 ft. long (2 sugar subsamples/plot)

Planted: May 1, 1996  
Harvested: October 21, 1996

Code No.	Variety	Source	Acre Yield		Beets/ 100'	Sucrose %	Beets/ 100'	Powdery Mildew Score	RJAP %
			Sugar Lbs	Beets Tons					
SR- 1	4KJ0169	Betaseed	10841	38.00	191	14.25	191	7.8	82.6
SR- 2	3BG6212	Betaseed	10874	34.37	179	15.82	179	7.5	79.9
SR- 3	96HX15	Holly	8075	28.88	196	13.98	196	7.5	81.1
SR- 4	3BG6170	Betaseed	9187	31.92	174	14.43	174	6.0	79.9
SR- 5	H92376	Spreckels	9203	32.94	190	14.00	190	7.8	79.7
SR- 6	HM 3056	Hilleshog	9429	31.71	189	14.88	189	8.0	80.2
SR- 7	Rhizosen CT	Holly	7594	27.30	200	13.86	200	7.0	82.7
SR- 8	H93747	Spreckels	9098	32.03	186	14.21	186	7.0	81.0
SR- 9	Beta 4035R	Betaseed	10433	35.70	191	14.61	191	6.3	81.9
SR-10	2J5324	Betaseed	8413	28.98	158	14.52	158	7.3	80.9
SR-11	95HX26	Holly	7457	26.78	194	13.92	194	8.0	82.8
SR-12	5CG7542	Betaseed	11547	41.90	156	13.79	156	6.8	82.2
SR-13	5CG7540	Betaseed	10078	36.75	194	13.70	194	7.0	81.1
SR-14	H92338	Spreckels	8246	28.98	179	14.23	179	7.3	80.6
SR-15	SS-NB7R	Spreckels	8684	30.66	185	14.16	185	7.5	81.3
SR-16	Rival	Holly	9015	30.87	189	14.60	189	7.8	80.9
SR-17	HM 3048	Hilleshog	8520	29.40	199	14.50	199	7.8	79.0
SR-18	3BG6224	Betaseed	11392	35.70	184	15.91	184	7.0	79.4
SR-19	4KJ0164	Betaseed	11589	39.80	183	14.56	183	6.8	82.6
SR-20	3BG6162	Betaseed	10695	37.70	186	14.19	186	6.8	81.1
SR-21	95HX25	Holly	9954	32.40	183	15.33	183	7.5	79.5
SR-22	SS-NB5R	Spreckels	9043	32.74	180	13.81	180	7.5	79.4
SR-23	3KJ5128	Betaseed	10999	37.49	149	14.69	149	6.3	81.0
SR-24	SS-IV3R	Spreckels	10626	37.17	186	14.30	186	7.0	80.8
SR-25	SS-289R	Spreckels	7980	27.75	195	14.36	195	8.3	81.5
SR-26	H93432	Spreckels	8998	30.24	173	14.88	173	7.3	81.1
SR-27	3BG6166	Betaseed	10811	36.86	175	14.65	175	6.0	81.4
SR-28	4581	Betaseed	10404	35.32	173	14.73	173	7.0	79.5
SR-29	HH-97R	Holly	7378	27.62	186	13.36	186	7.5	82.3
SR-30	3BG6226	Betaseed	9405	31.71	189	14.84	189	8.0	79.1
SR-31	4KJ0195	Betaseed	7326	26.15	130	14.00	130	7.5	81.5
SR-32	US H11	Check	6113	24.20	159	12.63	159	8.5	80.2

TEST 4096-2. CBGA SALINAS CODED RHIZOMANIA (MILD) TEST, SALINAS, CA., 1996

(cont.)

Code No.	Variety	Source	Acre Yield		Beets/100'	Sucrose %	Powdery Mildew		RJAP %
			Sugar Lbs	Beets Tons			No.	Score	
SR-33	SS-334R	Spreckels	8631	29.09		14.82	190	8.3	82.0
SR-34	4776R	Betaseed	11893	37.80		15.70	183	7.0	81.0
SR-35	HM3042	Hilleshog	10260	36.33		14.11	176	7.0	80.2
SR-36	96HX12	Holly	7857	28.04		14.01	180	7.5	81.6
SR-37	H944178	Spreckels	9252	33.08		14.02	196	7.3	80.3
SR-38	96HX11	Holly	10580	34.86		15.16	186	7.3	80.9
SR-39	3BG6188	Betaseed	10845	36.82		14.69	158	6.3	80.8
SR-40	SS-781R	Spreckels	9077	32.13		14.09	174	7.0	80.6
SR-41	4CG6596	Betaseed	9929	33.61		14.76	154	6.8	77.4
SR-42	95HX24	Holly	10971	35.28		15.54	158	7.8	78.5
SR-43	96HX14	Holly	8162	28.77		14.14	184	7.3	81.6
SR-44	HM 3057	Hilleshog	9422	31.92		14.77	194	7.5	80.0
SR-45	SS-NB2R2	Spreckels	8367	29.72		14.13	186	7.8	81.4
SR-46	SS-595R	Spreckels	7803	27.84		14.04	184	7.3	79.6
SR-47	4006R	Betaseed	9472	30.73		15.34	175	7.3	82.2
SR-48	Rhizoguard	Holly	7686	29.32		13.15	176	8.0	79.7
SR-49	SS-293R	Spreckels	7829	29.51		13.27	201	7.5	81.6
SR-50	96HX13	Holly	8089	28.67		14.11	178	7.8	82.1
SR-51	3BG6156	Betaseed	10961	37.49		14.66	189	6.0	81.1
SR-52	2J0152	Betaseed	10472	35.33		14.82	134	7.3	80.3
SR-53	HH-101R	Holly	8663	31.40		13.80	183	7.5	81.2
SR-54	H92326	Spreckels	9480	34.13		13.85	193	7.0	80.8
SR-55	4CG6575	Betaseed	9961	32.34		15.40	180	7.3	81.4
SR-56	SS-694R	Spreckels	8996	32.66		13.70	183	7.3	81.2
SR-57	HM 3055	Hilleshog	8809	29.94		14.74	189	7.5	81.8
SR-58	SS-287R	Spreckels	6539	25.20		12.93	190	7.5	80.0
SR-59	SS-IV2R	Spreckels	8897	31.40		14.18	190	7.5	80.4
SR-60	3BG6225	Betaseed	9068	30.45		14.89	179	7.3	80.3
SR-61	HH-102R	Holly	8750	30.14		14.49	178	7.0	81.6
SR-62	Rizor	SES F291	10110	31.19		16.20	205	8.0	79.0
SR-63	R578H50	USDA	9343	31.71		14.70	185	6.8	81.2
SR-64	US H11	USDA	6234	24.47		12.75	191	8.3	82.3
Mean			9247.1	32.05		14.39	180.9	7.3	80.8
LSD (.05)			1316.3	4.10		0.72	25.8	0.7	2.6
C.V. (%)			10.2	9.17		3.56	10.2	7.1	2.3
F value			8.1**	6.92**		7.85**	2.6**	4.6**	1.4NS

TEST 4096-2. CBGA SALINAS CODED RHIZOMANIA (MILD) TEST, SALINAS, CA., 1996

(cont.)

Code No.	Variety	Source	Acre Yield		Sucrose %	Beets/ 100' No.	Powdery Mildew		RJAP %
			Sugar Lbs	Beets Tons			Score		

NOTES: Rhizomania scored on 4 replications (4096-1). Rated on a scale of 0 to 9 where 0 = immune and 9 = dead. Most roots were rated 1,3,5, or 7 where 0-3 = resistant and 4-9 = susceptible.

Powdery mildew controlled August-September with Bayleton, then mildew developed late. Powdery mildew scored 09-30-96 on a scale of 0 to 9. Mildew probably had little affect on yield. Other foliar diseases were minimal. Other root diseases may have influenced yield: prior to thinning, a warm rain caused a tip rot (diagnosed as Phytophthora) which differentially reduced stands (particularly under severe rhizomania) and/or left plants without a tap root and fangy. Cyst nematode were evident at harvest and caused mild rhizomania-like symptoms.

Test 4096-1 was a plant-back to an area with sugarbeet in 1995. Test 4096-2 was not in sugarbeet in 1995. Both areas were inoculated with rhizomania in 1994. These areas were in the same plot field and otherwise had identical cultural practices.

RJAP = raw juice apparent purity.

For USDA entries (entries 62, 63, & 64), R578H50 =C790-15CMS x C78.

TEST B196. EVALUATION OF EXPERIMENTAL HYBRIDS, BRAWLEY, CA., 1995-96

32 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 12, 1995  
Harvested: May 14-15, 1996

Variety	Description <sup>1</sup>		Acre Yield		Sucrose	Bolters	Beets/100'		NO3-N
	CMS	T-O	Pollinator	Sugar			%	No.	
				Lbs	%	%			Score
<u>Checks</u>									
SS-IV2									
4006			Spreckels Hybrid (8-21-95)	9260		13.99	0.0	147	92.9
HH 41			Betaseed Hybrid (5103,8-28-95)	9164		15.61	0.0	152	92.3
US H11			Holly Hybrid (8-29-95)	9069		14.02	0.0	142	93.5
			C562 C36	6696		12.94	0.0	151	91.2
<u>Advanced lines x C78 tester</u>									
R578H37			C306	10985		14.11	0.0	141	93.9
R578H50			C790-15	9776		14.84	0.0	147	94.3
R578H52			C762-17	9611		13.55	0.0	138	94.4
R578H20			C562	9271		14.60	0.0	150	94.0
R578H51			C309	9211		14.20	0.0	144	93.7
R578H39			C762-17	9193		13.45	0.0	137	93.9
R578H8			C546	8681		13.90	0.0	144	94.8
R578H3			C562	7612		13.82	0.0	141	93.9
<u>Experimental F<sub>1</sub>CMS x C78 tester</u>									
R578H79			C790-15	10117		14.64	0.0	141	94.4
R578H80			C790-15	9785		13.88	0.0	146	95.0
R578H12			C790-15	9607		14.10	0.3	138	94.5
R578H76			C790-15	9454		14.12	0.3	145	93.8
R578H77			C790-15	9323		15.01	0.0	141	93.8
R578H75			C790-15	9216		13.68	0.0	143	95.3
R578H74			C790-15	9013		14.24	0.0	132	94.1
R578H78			C790-15	8679		14.20	0.3	144	93.9
<u>C76-43,-89 tester</u>									
R581H52			C762-17	10046		13.22	0.0	137	95.8
R581H51			C309	10015		13.94	0.4	135	95.6
R581H50			C790-15	9516		13.64	2.3	143	95.0
R581H12			C790-15	9088		13.48	0.0	135	95.2

TEST B196. EVALUATION OF EXPERIMENTAL HYBRIDS, BRAWLEY, CA., 1995-96

(cont.)

Variety	Description <sup>1</sup>		Acre Yield		Sucrose Bolters		Beets/ 100'		NO3-N Score	
	CMS	T-O	Pollinator	Sugar	Beets	%	%	No.		%
				Lbs	Tons					
C76-89-18 tester										
R576-89-18H52	C762-17	C790-15	C76-89-18	10280	36.44	14.09	0.0	143	95.3	186
R576-89-18H50	C790-15	C76-89-18		10028	35.62	14.10	0.7	141	95.0	190
Misc. pollinators										
4918H52	C762-17	C790-15	C918	10186	35.15	14.50	0.3	140	93.8	157
R480-45H52	C762-17	C790-15	C80-45	9896	35.02	14.06	0.0	130	93.5	189
R522H52	C762-17	C790-15	C51	9398	34.38	13.64	2.1	135	93.0	218
5911-4H50	C790-15	C911-4		9275	32.56	14.23	0.0	147	93.0	129
R540H52	C762-17	C790-15	RZM R40(C)	9221	33.90	13.59	0.0	144	93.3	182
5921H52	C762-17	C790-15	RZM R21(C)	9052	33.44	13.53	0.0	131	93.8	168
Mean				9384.7	33.37	14.05	0.2	141.5	94.1	174.2
LSD (.05)				962.9	2.61	0.96	0.7	11.8	1.3	53.5
C.V. (%)				10.4	7.93	6.93	332.4	8.4	1.4	31.2
F value				5.0**	8.35**	2.36**	5.0**	1.7NS	4.5**	2.6*

<sup>1</sup>R478NB = C78. R481-43,-89 = C76-43,-89. R476-89-18 = C76-89-18. R280-45 = C80-45. 3918 = C918. 4911-4 = C911-4. R22(C) = C51. R40(C) = composite C79-# series.

CMS lines: H39 = C762-17CMS x T-O; H26 = C309CMS x T-O; H3 = 562CMS x T-O; H50 = C790-15CMS x T-O. F92-790-15CMS = C790-15CMS. F82-562HO = C562CMS. U87-309 = C309. F82-546 = C546. 91=762-17CMS = C762-17CMS. 859-2,... are early generation monogerm, O-types selected as progenies for resistance to rhizomania.

NOTES: Test did not appear to be infected with rhizomania. No severe disease problems. Empoasca and powdery mildew not controlled and moderate at harvest. One sugar sample per plot for USDA tests; two sugar samples for coded variety trials. Sugar and impurity analyses for all tests by Holly Sugar Company.

TEST B296. HYBRID EVALUATION OF MULTIGERM POLLINATORS, BRAWLEY, CA., 1995-96

32 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 12, 1995  
Harvested: May 15, 1996

Variety	Description <sup>1</sup>	Acre Yield		Sucrose	Bolters	Beets/100'		NO3-N
		Sugar	Beets			No.	Beets	
		Lbs	Tons			%	%	
Checks								
R578H37	4807HO (C306CMS) x RZM R478NB	11250	39.87	14.11	0.3	134	93.6	100
SS-IV3	Spreckels (8-21-95)	9589	32.40	14.82	0.0	136	92.2	121
US H11	11-16-94	7806	28.43	13.74	0.0	145	91.9	122
Topcross Hybrids								
R576-89-18H50	F92-790-15CMS x R476-89-18	11348	37.43	15.18	0.0	139	93.8	143
5913-71H50	F92-790-15CMS x RZM 4913-71	11040	39.40	14.02	0.0	144	93.3	152
R576-89-18H50(Iso)								
	F92-790-15CMS x RZM R476-89-18	10920	36.01	15.18	0.0	145	93.4	108
R576-89-5H50	F92-790-15CMS x RZM R476-89-5	10917	35.39	15.46	0.0	138	93.7	119
5911-4H50(Iso)	F92-790-15CMS x NB-ER-RZM 3911-4	10750	37.14	14.47	0.0	144	92.6	128
R576-43-14H50	F92-790-15CMS x RZM R476-43-14	10624	34.80	15.28	0.0	138	94.5	123
R581H50	F92-790-15CMS x RZM R481-43,-89	10556	38.16	13.84	0.7	143	95.3	175
5913-70H50	F92-790-15CMS x RZM 3913-70	10533	35.58	14.80	0.0	141	92.2	94
5911-4H50(Sp)	F92-790-15CMS x RZM 4911-4m	10435	34.75	15.04	0.0	140	91.7	113
4918H50	F92-790-15CMS x RZM 3918	10336	34.20	15.11	0.7	134	92.6	138
5915H50	F92-790-15CMS x RZM-S 3915	10240	34.95	14.64	0.0	146	91.9	125
R576-43-15H50	F92-790-15CMS x RZM R476-43-15	10235	34.50	14.87	0.0	142	94.3	125
R480-45H50	F92-790-15CMS x R280-45	10217	34.24	14.98	0.0	137	93.4	116
R578H50-#	4790-15-#(C)CMS x RZM R478NB	10207	36.31	14.06	1.0	139	95.2	156
RR544R2H50	F92-790-15CMS x RZM R444	10060	35.03	14.38	0.0	150	91.8	147
R578H50	F92-790-15CMS x RZM R478NB	10052	33.53	15.02	0.0	149	93.1	124
R578H50-21	4790-15-21CMS x RZM R478NB	9893	35.22	14.05	0.3	146	94.1	156
RR543R2H50	F92-790-15CMS x RZM R443	9837	33.91	14.53	1.4	142	93.6	174
RR540H50	F92-790-15CMS x RZM R40(C)	9745	34.97	13.93	0.6	141	92.6	164
R578H50-23	4790-15-23CMS x RZM R478NB	9538	33.31	14.26	0.0	142	93.3	131

(cont.)

Variety	Description <sup>1</sup>	Acre Yield		Beets/ 100'		Clean	
		Sugar	Beets	Sucrose	Bolters	Beets	NO3-N
		Lbs	Tons	%	%	No.	Score
Topcross Hybrids (cont.)							
5921H50	F92-790-15CMS x RZM R21(C)	9524	33.44	14.23	0.3	145	91.8
R522H50	F92-790-15CMS x RZM R22(C)	9173	32.63	14.05	3.0	140	92.4
Population Hybrids							
R581H87	RZM 4890aa x RZM R481-43,-89	11110	39.36	14.11	0.0	147	95.9
R581H10	4911-4H90aa x RZM R481-43,-89	10650	39.39	13.55	0.0	137	94.6
R578H65	4865aa x RZM R478NB	9994	34.60	14.43	0.0	142	91.1
R576-89-18H65	4865aa x R476-89-18	9878	33.79	14.62	0.0	148	94.7
R581H65	RZM 4865aa x RZM R481-43,-89	9701	35.27	13.79	0.0	142	95.4
R578H94	4894aa x RZM R478NB	9640	33.82	14.25	0.0	135	95.7
R578H93	4893aa x RZM R478NB	8918	31.34	14.20	0.7	145	94.1
Mean		10147.3	35.10	14.47	0.3	141.7	93.4
LSD (.05)		928.5	2.86	0.71	0.8	10.7	1.8
C.V. (%)		9.3	8.26	4.98	277.1	7.7	1.9
F value		4.9**	5.74**	4.04**	4.8**	1.3NS	4.4**
							1.4NS

<sup>1</sup>RZM = parental component is mother roots mass selected for resistance to rzm. NB = selected for nonbolting.

F92-790-15CMS = C790-15CMS x C790-15. 4790-15-#, -21, -23 are selections from C790-15 for NB. 4890aa = genetic ms plants from C890. R280-45 = C890-45. 3918 = C918. R478NB = C78. R481-43,-89 = C76-43,-89. R476-89-18 = C76-89-18. R476-89-5 = C76-89-5. R476-43-14 = C76-43-14. R476-43-15 = C76-43-15. 4911-4 = C911-4. 3913-70 = C913-70. R22(C) = C51. R40(C) = Composite of C79-# series. R21(C) = composite of crosses to R22. R443 & R444 = lines with R22 (C51) resistance to rzm.

**NOTES:** Test did not appear to be infected with rhizomania. No severe disease problems. Powdery mildew and Empoasca not controlled and moderate at harvest.



TEST B396. AREA 5 CODED REGULAR VARIETY TRIAL, BRAWLEY, CA., 1995-96

16 entries x 8 replications, RCB (equalized)  
2-row plots, 27 ft. long

Planted: September 12, 1995  
Harvested: May 17-18, 1996

Code	Variety	Source	Acre Yield		Sucrose %	Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
			Sugar Lbs	Beets Tons					
CBGA entries									
9	95HX23	Holly	9885	29.48	16.78	129	0.0	91.9	110
8	94HX28	Holly	10200	33.49	15.24	137	0.0	92.7	195
3	HM 3013	Hilleshog	9889	33.20	14.85	128	0.0	89.5	198
2	SS-IV1	Spreckels	10156	34.85	14.62	134	0.0	92.9	217
7	93HX30	Holly	9875	32.27	15.29	136	0.0	92.5	234
4	SS-IV3	Spreckels	9669	32.62	14.83	133	0.0	92.2	211
12	HH-51	Holly	9829	33.78	14.56	132	0.2	92.5	233
10	H93778	Spreckels	10088	35.83	14.08	137	0.2	93.8	258
1	HM 3005	Hilleshog	9579	32.45	14.75	131	0.2	91.6	178
11	SS-IV2	Spreckels	9784	33.69	14.53	143	0.0	91.2	201
13	Beta 4684	Betaseed	9477	32.80	14.51	125	0.0	93.1	232
5	HM 3012	Hilleshog	9052	31.37	14.43	137	0.2	92.2	156
6	US H11	USDA	8027	28.83	13.93	118	0.0	89.7	280
USDA entries									
15	R578H50	USDA	10833	36.29	14.92	136	0.2	92.9	198
16	R581H50	USDA	10872	38.42	14.23	123	1.0	93.9	301
14	R578H37	USDA	10224	36.99	13.82	138	0.0	93.0	220
Mean			9840.0	33.52	14.71	132.3	0.1	92.2	214.0
LSD (.05)			591.0	1.93	0.57	10.5	0.4	1.2	59.4
C.V. (%)			6.1	5.83	3.89	8.0	306.5	1.3	28.1
F value			8.3**	12.33**	7.35**	1.5NS	3.9**	7.1**	2.7

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH <sub>4</sub> -N ppm	Impur. Value
<u>CBGA entries</u>									
9	95HX23	8734	297	88.3	1151	364	2172	668	13053
8	94HX28	8733	261	85.6	1468	399	2594	700	14529
3	HM 3013	8381	252	84.7	1508	424	2608	751	15141
2	SS-IV1	8349	241	82.1	1807	606	2879	834	17237
7	93HX30	8338	258	84.4	1537	368	2751	812	15878
4	SS-IV3	8252	253	85.3	1417	400	2561	703	14477
12	HH-51	8203	243	83.3	1627	393	2791	808	16029
10	H93778	8166	228	80.8	1922	534	3203	842	17874
1	HM 3005	8140	251	84.9	1439	505	2570	691	14757
11	SS-IV2	8093	241	82.6	1692	507	2772	844	16719
13	Beta 4684	7825	240	82.6	1652	483	2747	847	16603
5	HM 3012	7503	239	82.8	1550	404	2734	867	16481
6	US H11	6598	229	82.2	1429	384	2784	865	16524

USDA entries

15	R578H50	9078	250	83.7	1755	375	2825	817	16138
16	R581H50	9002	236	82.8	1870	514	2883	760	16224
14	R578H37	8237	223	80.5	1986	460	3302	847	17912
Mean		8227.0	246.3	83.5	1613.0	444.9	2760.9	791.0	15973.5
LSD (.05)		575.2	13.3	1.9	178.4	83.6	235.1	97.0	1668.1
C.V. (%)		7.1	5.5	2.2	11.1	19.0	8.6	12.4	10.5
F value		6.3**	7.8**	5.8**	9.3**	4.8**	8.8**	3.1**	4.8**

NOTES: No apparent rhizomania. Entries 14, 15, & 16 were added by tester as fillers:  
R578H37 = C306CMS x C78; R578H50 = C790-15CMS x R78; R581H50 = C790-15CMS x C76-43 & C76-89.

TEST B596. EVALUATION OF LINES UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96

24 entries x 8 replications, RCB (equalized); 3 subsets: 8 x 8, RCB (e) Planted: September 12, 1995  
1-row plots, 18 ft. long Harvested: May 21-22, 1996

Variety	Description	Acre Yield		Sucrose	Bolters	Root	Beets/ 100'	Clean Beets	NO3-N
		Sugar Lbs	Beets Tons	%	%	%	No.	%	Score

B596-1: 8 varieties x 8 reps, LS. MULTIGERM, OPEN-POLLINATED LINES

US H11	11-16-94	3828	16.12	11.76	0.0	4.5	100	89.0	105
Rival	HH103, L1031203 (8-29-95)	6797	22.15	15.34	0.0	0.0	101	93.6	99
R578(Sp)	RZM R478NB, (C78)	6040	20.40	14.67	0.0	0.0	98	92.7	95
R580	NB-ER-RZM R380,Y, (C80NB)	6118	21.15	14.38	0.0	0.0	97	92.2	111
R581	RZM R481-43,-89, (C76-43,-89)	6482	22.98	14.09	0.0	0.0	90	94.8	155
Y562	RZM Y462	6009	20.91	14.05	0.0	0.0	92	92.7	105
Y563	RZM Y463	6114	21.05	14.31	0.0	2.8	101	93.8	126
R539	NB-ER-RZM R137C7, (C39R)	5422	18.08	14.92	0.0	0.0	101	92.7	110
Mean		5851.2	20.36	14.19	0.0	0.9	97.8	92.7	113.0
LSD (.05)		1094.7	3.62	0.91	0.0	3.6	13.8	1.5	66.2
C.V. (%)		18.6	17.68	6.38	0.0	392.9	14.1	1.6	58.3
F value		5.6**	3.06NS	11.24**	0.0	1.9NS	0.8NS	10.5**	0.7NS

TEST B596. EVALUATION OF LINES UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96

24 entries x 8 replications, RCB (equalized); 3 subsets: 8 x 8, RCB (e). ANOVA to compare means across sets.

Mean	5833.8	20.19	14.33	0.3	0.4	95.1	91.6	109.2
LSD (.05)	1245.5	4.03	1.06	2.0	2.3	15.8	2.2	63.9
C.V. (%)	21.7	20.27	7.54	595.8	535.4	16.8	2.4	59.4
F value	4.9**	5.62**	4.10**	4.6**	1.7*	1.3NS	3.1**	1.1NS

TEST B596. EVALUATION OF LINES UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96

(cont.)

Variety	Description	Acre Yield		Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Clean Beets %	NO3-N Score
		Sugar	Beets						
		Lbs	Tons						
B596-2: 8 varieties x 8 reps, LS. LINES WITH R22 & C79-# GERMPPLASM									
R522 (Sp)	RZM-%S R322R4,Y3, (C51)	7519	26.46	14.25	7.3	0.0	90	90.9	113
Y564 (Iso)	RZM 4205,P;6,P;7,P;8,P	7073	24.76	14.30	0.0	0.0	94	91.9	118
R540%(Iso)	RZM-%S 3201-3285, (C79-#'s)	6488	21.75	14.64	0.0	0.0	100	91.8	146
R543R2	RZM R443	7382	24.43	15.00	0.0	0.0	99	91.7	123
5920	RZM 4287	5322	18.86	13.94	0.0	0.0	90	90.7	127
5921 (Sp)	RZM R422Y3H15,...	6433	22.77	14.22	0.0	0.0	90	91.3	123
5922	RZM R440H18	4793	15.99	14.75	0.0	0.0	92	90.9	66
5810	0790mmaa x 4265-4279	4198	14.71	14.09	0.0	0.0	104	90.7	67
Mean		6151.0	21.22	14.40	0.9	0.0	94.9	91.2	110.1
LSD (.05)		1297.9	3.96	1.04	3.2	0.0	14.8	2.7	58.4
C.V. (%)		21.0	18.57	7.17	350.0	0.0	15.5	3.0	52.8
F value		7.4**	9.45**	0.98NS	5.2**	0.0	1.2NS	0.3NS	2.0NS

**B596-3: 8 varieties x 8 reps, LS. MULTIGERM & MONOGERM POPULATIONS**

5915	RZM(C)aa x RZM(C)A	5809	19.28	14.72	0.0	0.0	99	89.8	95
5925	S <sub>1</sub> (C)aa x RZM S <sub>1</sub> (C)A	5407	18.82	14.02	0.0	0.0	74	90.0	101
5911-4M	RZM 4911-4Maa x A, (C911-4)	4731	16.98	13.68	0.0	0.0	95	91.7	88
5923	4918aa x R40(C)	6067	19.96	15.03	0.0	0.0	94	90.4	92
5924	RZM 4918aa x Y-#(C1)(C2)	5765	20.37	14.00	0.0	0.0	90	92.6	140
R544R2	RZM R444	6897	26.20	13.14	0.0	1.0	95	91.5	149
5818	RZM 4270,2, (C890-8)	4686	15.44	15.08	0.0	1.9	104	90.2	71
5869	3,4867(C)mmaa x 3890(C)A	4631	14.99	15.48	0.0	0.0	92	91.6	100
Mean		5499.3	19.00	14.39	0.0	0.4	92.7	91.0	104.5
LSD (.05)		1159.9	3.93	1.11	0.0	1.6	16.4	1.9	58.2
C.V. (%)		21.0	20.57	7.68	0.0	433.8	17.6	2.1	55.4
F value		1.7NS	6.55**	4.26*	0.0	1.7NS	2.2NS	2.1NS	1.7NS

TEST B596. EVALUATION OF LINES UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96

(cont.)

Variety	Description	Acre Yield		Bolters %	Root Rot %	Beets/ 100' No.	Clean Beets %	NO3-N Score
		Sugar Lbs	Beets Tons					

NOTES: Test B596 had moderate to severe rhizomania. It was in an area that did not have rhizomania tests in 1995, but did have in 1994. Problems were encountered obtaining normal stands and stand counts were consistently low. Yield was adjusted in proportion to missing feet of row. At harvest there were few rotted or dead beets, but there was evidence that rhizomania susceptible plants would not have survived much later into the season.

Test B696 was not harvested. It had severe rhizomania and was in an area that had had rhizomania tests in 1994 and 1995. Test B696 had a similar set of entries as test B596. Based upon visual ratings, lines without Rz were mostly dead. Plants in lines with only Rz were poor. Plants in lines with R22 (C51) germplasm were obviously better for vigor and survivability. Entry R522 (C51) was best. Lines with R22 in pedigree were segregating for tolerance and survivability under these conditions.

TEST B796. EVALUATION OF HYBRIDS UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96 (B796)

48 entries x 8 replications, RCB (equalized); 3 subsets: 16 x 8, RCB (e) Planted: September 13, 1995  
1-row plots, 18 ft. long Harvested: May 20-21, 1996

Variety	Description	Acre Yield		Sucrose %	Bolters %	Root Rot %	Beets/100' No.	Clean Beets %	NO3-N Score
		Sugar	Beets						
		Lbs	Tons						
B796-1: 16 varieties x 8 reps, RCB(E)									
US H11	11-16-94	2899	10.44	13.89	0.0	5.4	114	88.8	15
	RZ3/1022 (1993)	6963	21.80	15.92	0.0	0.0	124	92.8	109
	HH103 (8-29-95)	6166	20.93	14.94	0.0	0.8	118	92.6	120
	4807HO (C306CMS) x RZM R478NB	5285	20.74	12.26	0.0	1.7	101	91.8	120
R578H50	F92-790-15CMS x RZM R478NB, C78	5856	19.73	14.62	0.0	0.0	115	92.2	83
	4911-4H50 x RZM R478NB, C78	5711	18.72	14.93	0.0	0.0	118	91.8	61
	4918aa x RZM R478NB, C78	5709	18.75	14.86	0.0	0.0	107	92.9	66
	F92-790-15CMS x RZM 4911-4	5274	17.61	14.73	0.0	2.3	133	90.3	61
R581H50	F92-790-15CMS x RZM R481-43,-89	6047	21.27	14.13	0.0	0.0	116	92.1	82
	4911-4H50 x RZM R481-43,-89	5967	19.80	14.65	0.0	0.7	108	92.1	72
	RZM 4918aa x RZM R481-43,-89	6601	22.75	14.16	0.0	0.7	110	92.7	128
	F92-790-15CMS x R476-89-18	5003	16.74	14.42	0.0	1.6	112	90.9	72
R576-89-18H50	RZM 4918aa x R476-89-18	5269	17.52	14.55	0.0	0.0	108	92.3	81
	F92-790-15CMS x RZM R576-89-5	6041	18.11	16.60	0.0	0.0	117	90.0	45
	F92-790-15CMS x RZM R576-43-14	6246	20.89	15.01	0.0	0.6	122	93.2	69
	F92-790-15CMS x RZM R576-43-15	5181	16.82	15.38	0.0	0.7	114	93.6	76
Mean		5638.8	18.91	14.69	0.0	0.9	114.8	91.9	78.7
LSD (.05)		1292.7	4.26	0.89	0.0	2.7	11.5	1.9	44.8
C.V. (%)		23.2	22.77	6.14	0.0	304.0	10.2	2.1	57.4
F value		3.9**	3.64**	8.62**	0.0	2.1*	3.3**	3.6**	3.4**

TEST B796. EVALUATION OF HYBRIDS UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96 (B796)

48 entries x 8 replications, RCB (equalized); 3 subsets: 16 x 8, RCB (e). ANOVA to compare means across sets.

Mean	5482.0	18.61	14.57	0.1	1.1	114.2	91.0	73.7
LSD (.05)	1349.2	4.67	0.88	0.6	5.4	12.3	2.0	51.0
C.V. (%)	25.0	25.46	6.11	698.9	506.1	10.9	2.2	70.2
F value	5.4**	5.15**	4.89**	2.0	1.3NS	2.5**	5.5**	2.5**

TEST B796. EVALUATION OF HYBRIDS UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96 (B796)

(cont.)

Variety	Description	Acre Yield		Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Clean Beets %	NO3-N Score
		Sugar	Beets						
		Lbs	Tons						
B796-2: 16 entries x 8 reps, RCB(E)									
Rhizoguard	L892301 (8-30-94)	4714	16.19	14.70	0.0	1.3	114	93.6	83
SS-781R	L941000 (8-21-95)	6398	20.95	15.27	0.0	0.0	113	94.2	45
5913-70H50	F92-790-15CMS x RZM 3913-70	5533	18.71	14.59	0.0	0.0	126	88.0	60
5913-71H50	F92-790-15CMS x RZM 4913-71	5582	18.61	14.77	0.0	0.6	117	90.1	49
R543R2H50	F92-790-15CMS x RZM R443	6299	20.78	15.18	0.0	0.0	118	91.9	84
R544R2H50	F92-790-15CMS x RZM R444	6503	22.28	14.53	0.0	0.0	122	90.4	58
R522H50	F92-790-15CMS x RZM R22(C), C51	8094	27.17	14.93	0.7	0.0	104	91.0	105
R540H50	F92-790-15CMS x RZM R40(C)	5493	18.71	14.60	0.0	0.6	108	91.2	80
5921H50	F92-790-15CMS x RZM R21(C)	5801	20.36	14.15	0.0	2.1	103	90.9	90
R578H65	4865m,aa x RZM R478NB, C78	5560	18.27	15.08	0.0	0.6	110	91.7	65
R578H87	4890m,aa x RZM R478NB, C78	4712	16.08	14.39	0.0	1.2	111	89.9	52
R578H93	4893aa x RZM R478NB, C78	5806	20.90	13.75	0.6	0.0	112	92.5	106
R578H94	4894aa x RZM R478NB, C78	4807	16.54	13.89	0.0	2.0	102	91.0	97
5923	4918aa x RZM R40(C)	5395	18.60	14.35	0.0	0.0	99	91.3	72
5912H18	4918aa x RZM R21(C)	6508	22.08	14.66	0.0	0.0	110	92.4	79
R522H18	4918aa x RZM R22(C), C51	7756	27.54	14.13	1.9	0.0	104	92.7	141
Mean		5935.2	20.24	14.56	0.2	0.5	110.9	91.4	79.2
LSD (.05)		1402.5	5.00	0.78	1.0	1.9	13.4	2.1	53.3
C.V. (%)		23.9	24.96	5.44	479.3	370.6	12.2	2.3	68.0
F value		3.8**	3.58**	2.47**	2.3**	1.2NS	2.5*	4.2**	1.8NS

TEST B796. EVALUATION OF HYBRIDS UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96 (B796)

(cont.)

Variety	Description	Acre Yield			Sucrose %	Bolters %	Root Rot %	Beets/ 100' No.	Clean Beets %	NO3-N Score
		Sugar	Beets							
		Lbs	Tons							
B796-3: 16 entries x 8 reps, RCB(E)										
Hybrid evaluation of C79-# series										
R522H50	F92-790-15CMS x RZM R22(C), (C51)	8018	28.37	14.18	0.7	0.0	110	90.0	135	
R578H50	F92-790-15CMS x RZM R478NB, (C78)	5640	18.55	15.06	0.0	1.3	118	91.1	58	
4006	Betaseed 4006.5103 (8-28-95)	5767	18.96	15.12	0.0	0.6	124	91.1	60	
US H11	11-16-94	3252	12.40	12.96	0.0	13.8	116	88.8	30	
R479H50	F92-790-15CMS x RZM R379	3612	13.81	13.06	0.0	2.2	115	92.2	89	
R579H50	F92-790-15CMS x RZM R479, C79-1	4652	15.70	14.54	0.0	2.1	114	90.7	67	
R524H50	F92-790-15CMS x RZM R424, C79-2	4577	14.78	15.06	0.0	0.0	115	90.1	47	
R525H50	F92-790-15CMS x RZM R425, C79-3	3499	11.61	14.91	0.0	0.5	117	87.9	32	
R528H50	F92-790-15CMS x RZM R428, C79-4	3609	12.45	14.14	0.5	1.7	120	89.5	46	
R532H50	F92-790-15CMS x RZM R432, C79-5	5276	17.68	14.74	0.0	1.1	115	86.8	62	
R534H50	F92-790-15CMS x RZM R434, C79-6	4639	15.78	14.35	0.0	4.9	120	89.1	37	
R535H50	F92-790-15CMS x RZM R435, C79-7	4539	15.13	14.99	0.0	1.0	121	89.5	44	
R536H50	F92-790-15CMS x RZM R436, C79-8	6844	23.51	14.47	0.0	0.0	122	90.6	94	
R537H50	F92-790-15CMS x RZM R437, C79-9	4352	14.65	14.66	0.0	0.6	116	88.1	30	
R541H50	F92-790-15CMS x RZM R441, C79-10	5079	17.33	14.66	0.0	0.0	111	90.2	70	
R542H50	F92-790-15CMS x RZM R442, C79-11	4593	16.00	14.33	0.0	0.0	118	90.3	112	
Mean		4872.0	16.67	14.45	0.1	1.8	117.0	89.7	63.2	
LSD (.05)		1167.4	4.12	0.66	0.6	8.8	11.7	2.0	50.9	
C.V. (%)		24.2	24.96	4.58	782.9	482.4	10.1	2.6	81.3	
F value		9.1**	8.50**	7.58**	1.0NS	1.2NS	0.8NS	3.7**	2.8*	

NOTES: Test B796 was under severe rhizomania. It was grown in an area that had had rhizomania tests in 1994 and 1995. Stands were low but not extremely variable. Where gaps did occur, yield was adjusted in proportion to the missing feet of row. At harvest, there was evidence that rhizomania susceptible plants would not have survived much later into the season.



TEST B796. EVALUATION OF HYBRIDS UNDER RHIZOMANIA, BRAWLEY, CA., 1995-96 (B796)

(cont.)

Variety	Description	Acre Yield		Sucrose	Bolters	Root	Beets/ 100'	Clean Beets	N03-N
		Sugar Lbs	Beets Tons						
				%	%	%	No.	%	Score

NOTES: (cont.)

Rhizomania tests in Imperial Valley have high variability (high CV's). Rhizomania or the cultural practices that lead to rhizomania seem to cause difficulties in the fall with seedling vigor, survival, and stand establishment. Then after somewhat normal winter growth, the warm spring and summer conditions, which reactivate rhizomania, again cause variability. Within the field plot area, severity of rhizomania also appears to change abruptly, that is, in these heavy clay soils, this inoculum/infection potential seems to be highly variable. Except for extreme differences in resistance, variety reaction to rhizomania is more difficult to measure than at Salinas. Also root symptoms (bearding) are not so clear cut. Irrigation frequency with these heavy soils and with cool winter conditions may lead to only a few potential cycles of reinfection per season, unlike Salinas where rhizomania tests are sprinkler irrigated about every five days during the summer.

TEST B896. AREA 5 CODED RHIZOMANIA VARIETY TRIAL, BRAWLEY, CA., 1995-96

32 entries x 8 replications, RCB (equalized)  
1-row plots, 27 ft. long

Planted: September 13, 1995  
Harvested: May 16-17, 1996

Code	Variety	Source	Acre Yield		Sucrose %	Beets/ 100' No.	Bolters %	Clean Beets %	NO3-N Mean
			Sugar Lbs	Beets Tons					
CBGA entries									
9	Beta 4006R	Betaseed	9330	30.91	15.13	137	0.0	91.2	68
1	95HX24	Holly	9317	29.29	15.96	127	0.0	93.3	128
21	H92326	Spreckels	9182	30.75	14.97	127	0.0	93.7	113
6	95HX25	Holly	8935	29.69	15.11	130	1.4	93.7	105
19	Beta 4035R	Betaseed	8940	32.19	13.91	138	0.0	93.1	111
22	4CG6575	Betaseed	8985	29.95	15.01	131	0.0	94.3	123
25	Rival	Holly	8875	30.12	14.84	125	0.3	94.0	126
16	HM 3057	Hilleshog	8582	32.43	13.29	136	10.7	92.1	133
15	SS-IV2R	Spreckels	8513	30.69	13.91	125	0.0	93.1	117
26	5CG7540	Betaseed	8627	31.21	13.88	92	2.0	92.2	162
27	5CG7542	Betaseed	8156	30.95	13.27	37	1.0	94.9	144
13	SS-IV3R	Spreckels	7953	30.03	13.43	134	0.0	92.8	135
8	2J0152	Betaseed	7859	27.43	14.38	58	0.0	93.6	161
4	Beta 4581	Betaseed	8157	30.24	13.48	126	0.0	93.4	194
17	Beta 4776R	Betaseed	7571	25.12	15.14	85	0.0	92.9	84
7	SS-781R	Spreckels	7447	28.93	12.96	125	0.0	94.4	158
5	HM 3048	Hilleshog	7221	26.60	13.51	127	0.3	90.8	125
14	HM 3056	Hilleshog	7294	26.21	13.98	124	0.0	91.7	100
3	H93694	Spreckels	7239	28.01	12.96	133	0.0	93.0	156
2	HH-97R	Holly	6703	24.34	13.79	133	0.0	91.9	67
20	Rhizoguard	Holly	6899	24.79	13.94	127	0.0	93.8	102
10	HM 3055	Hilleshog	6801	26.09	13.20	127	0.0	90.7	109
12	95HX26	Holly	5954	21.56	13.79	125	0.0	93.1	87
18	SS-IV2	Check	5826	23.20	12.48	143	0.0	90.5	56
11	HM 3013	Check	5106	20.21	12.80	135	0.0	88.1	37
24	Beta 4684	Check	5067	19.67	12.92	136	0.0	90.2	63
23	US H11	Check	4569	18.48	12.40	123	0.0	88.1	76

TEST B896. AREA 5 CODED RHIZOMANIA VARIETY TRIAL, BRAWLEY, CA., 1995-96

(cont.)

Code	Variety	Source	Acre Yield		Sucrose %	Beets/ 100'	Bolters %	Clean Beets %	NO3-N Mean
			Sugar	Beets					
			Lbs	Tons					
USDA entries									
28	Rizor	SES	9914	31.24	15.87	138	0.0	92.8	128
30	R578H50	USDA	8730	29.60	14.74	130	0.0	93.0	87
31	R581H50	USDA	8522	29.63	14.44	135	0.3	93.6	94
32	R522H50	USDA	8670	30.27	14.40	131	2.5	91.3	133
29	R578H37	USDA	8586	31.36	13.79	128	0.0	90.9	96
Mean									
LSD (.05)			7797.8	27.85	13.99	122.7	0.6	92.4	111.7
C.V. (%)			1078.8	3.65	0.77	11.9	1.5	1.7	44.9
F value			14.1	13.32	5.60	9.9	267.0	1.9	40.8
			12.4**	8.63**	11.43**	28.7**	12.7**	7.7**	4.8**

NOTES: Test had moderate rhizomania. Root and sugar yield was adjusted in proportion to missing feet of row. Stands were consistently poor for entries 8 and 27 and weak for entries 17 and 26, giving the test an uneven appearance.

Entries 28 through 32 were used as fillers and checks by the tester: R578H37 = C306CMS x C78; R578H50 = C790-15CMS x C78; R581H50 = C790-15CMS x C76-43 & C76-89; and R522H50 = C790-15CMS x C51.

TEST B896. AREA 5 CODED RHIZOMANIA VARIETY TRIAL, BRAWLEY, CA., 1995-96

(cont.)

Code	Variety	Recover.		Recover.		Sugar lbs/a	Sugar lbs/t	Sugar %	Known SugarLoss lbs/a	Sodium		Potassium		NH <sub>4</sub> -N		Impur. Value
		Sugar lbs/a	Sugar lbs/t	ppm	ppm					ppm	ppm					
CBGA entries																
9	Beta 4006R	8482	275	90.9	848	556	1498	365								9159
1	95HX24	8250	283	88.5	1067	476	2100	548								12125
21	H92326	8165	267	88.8	1016	667	1951	391								10922
6	95HX25	7971	270	89.1	964	530	1865	445								10742
19	Beta 4035R	7833	244	87.6	1106	633	2127	405								11380
22	4CG6575	7806	261	86.7	1179	684	2238	538								13096
25	Rival	7736	260	87.3	1139	608	2159	512								12385
16	HM 3057	7530	234	87.8	1052	787	2053	289								10629
15	SS-IV2R	7494	245	87.9	1019	616	1991	406								10993
26	5CG7540	7449	240	86.4	1177	891	2076	431								12401
27	5CG7542	6937	227	85.0	1219	876	2462	387								12896
13	SS-IV3R	6921	236	87.4	1032	708	1970	378								10991
8	2J0152	6898	253	87.7	960	883	2044	356								11586
4	Beta 4581	6880	228	84.0	1277	776	2335	574								14004
17	Beta 4776R	6776	272	89.7	794	573	1731	411								10235
7	SS-781R	6360	223	85.4	1087	812	2006	452								12155
5	HM 3048	6245	233	86.0	976	792	2281	417								12436
14	HM 3056	6243	240	85.7	1052	805	2127	535								13217
3	H93694	6184	222	85.1	1055	814	2161	444								12472
2	HH-97R	6064	250	90.6	639	595	1767	216								8550
20	Rhizoguard	6049	245	87.7	850	773	2021	371								11285
10	HM 3055	5813	227	85.4	987	828	2150	431								12368
12	95HX26	5299	245	88.5	655	777	1872	290								10153
18	SS-IV2	5148	221	88.5	677	804	1917	208								9585
11	HM 3013	4542	229	89.2	564	665	2046	164								9001
24	Beta 4684	4505	231	88.9	562	715	1845	216								9171
23	US H11	4034	220	88.2	536	646	2032	220								9429

TEST B896. AREA 5 CODED RHIZOMANIA VARIETY TRIAL, BRAWLEY, CA., 1995-96

(cont.)

Code	Variety	Recover. Sugar lbs/a	Recover. Sugar lbs/t	Recover. Sugar %	Known SugarLoss lbs/a	Sodium ppm	Potassium ppm	NH <sub>4</sub> -N ppm	Impur. Value
<u>USDA entries</u>									
28	Rizor	8752	280	88.2	1161	540	2074	552	12318
30	R578H50	7713	260	88.0	1018	567	2196	421	11475
31	R581H50	7591	258	89.1	931	581	2012	337	10270
32	R522H50	7357	245	84.7	1313	501	2384	685	14221
29	R578H37	7345	237	85.6	1241	778	2501	414	12905
Mean		6824.2	245.6	87.5	973.6	695.5	2062.3	400.2	11392.3
LSD (.05)		997.9	17.3	2.0	170.1	153.9	198.9	79.9	1323.5
C.V. (%)		14.9	7.2	2.3	17.7	22.5	9.8	20.3	11.8
F value		11.3**	8.8**	6.0**	12.5**	4.8**	8.6**	17.3	9.9**

TEST B496. CARRY-OVER EFFECTS OF SOIL FUMIGATION & SOLARIZATION, BRAWLEY, CA., 1995-96

4 soil trtmts x 3 var. x 2 harv. dates x 4 reps, Split-Split Block  
 2-row plots, 12 ft. long  
 Planted: September 13, 1995  
 Harvested: May 22 & July 2, 1996

Treatment	Acre Yield			Harvest Count No.	Clean Beets %	NO3-N Mean	Beets/ 100' No.	Root Rot %
	Sugar Lbs	Beets Tons	Sucrose %					
Soil Treatments (S)								
1. Control	3286	13.02	12.57	20	88.8	76.0	82	24.1
2. Solarization	8288	27.89	14.77	31	91.8	63.4	131	7.6
3. Vapam	5025	18.84	12.92	21	91.2	74.7	86	21.3
4. Methylbromide	5933	21.10	13.94	28	91.1	62.8	117	12.1
Varieties (V)								
1. HH 41	4128	15.29	12.78	23	89.7	60.0	99	23.6
2. 4006	5394	17.55	14.92	27	91.6	62.0	113	14.2
3. 5921H52	7377	27.79	12.95	24	90.9	85.6	100	11.0
Harvest Date (H)								
1. May 22, 1996	6436	21.72	14.68	28	90.4	62.5	119	4.7
2. July 2, 1996	4831	18.71	12.42	21	91.1	76.0	89	27.9
S x V								
1 x 1	1738	6.78	12.33	17	86.6	66.5	71	37.6
1 x 2	3134	11.65	13.57	24	89.2	70.9	99	18.6
1 x 3	4987	20.63	11.82	19	90.6	90.6	78	16.0
2 x 1	7492	26.22	14.04	31	91.4	55.9	129	10.2
2 x 2	7566	23.67	15.84	34	92.8	55.4	141	6.9
2 x 3	9807	33.79	14.43	29	91.3	78.9	123	5.8
3 x 1	2738	10.92	11.70	19	90.4	60.4	80	29.8
3 x 2	5325	17.26	14.90	23	92.3	63.4	94	20.2
3 x 3	7014	28.33	12.15	20	90.9	100.4	84	14.0
4 x 1	4545	17.26	13.03	28	90.5	57.4	115	16.7
4 x 2	5553	17.64	15.38	29	91.8	58.4	119	11.2
4 x 3	7702	28.41	13.41	28	90.9	72.4	116	8.3

NOTES: See test B695, 1995 Sugarbeet Research Report, pages A25-A29 & A122-A129 and summary at beginning of this Report "Effects of Solarization, Fumigation, Dates of Harvest, Varieties, and Crop History on Rhizomania and Soil-borne Pests in the Imperial Valley."

TEST B496. CARRY-OVER EFFECTS OF SOIL FUMIGATION & SOLARIZATION, BRAWLEY, CA., 1995-96

(cont.)

Treatment	Acre Yield		Sucrose %	Harvest Count No.	Clean Beets %	NO3-N Mean	Beets/ 100' No.	Root	
	Sugar Lbs	Beets Tons						Rot %	Rot %
<u>S x H</u> 1 x 1 1 x 2 2 x 1 2 x 2 3 x 1 3 x 2 4 x 1 4 x 2	4023	14.93	13.67	24	88.0	62.2	102	8.6	
	2549	11.11	11.48	15	89.6	89.8	64	39.5	
	8880	28.76	15.49	33	91.5	62.6	138	0.0	
	7696	27.02	14.05	30	92.2	64.2	123	15.2	
	6592	22.72	14.45	26	91.1	62.5	110	4.1	
	3459	14.95	11.38	15	91.3	87.0	63	38.6	
	6248	20.45	15.11	30	91.0	62.7	127	6.0	
	5618	21.76	12.77	26	91.2	62.8	107	18.1	
<u>V x H</u> 1 x 1 1 x 2 2 x 1 2 x 2 3 x 1 3 x 2	5135	17.84	14.21	29	89.8	62.1	119	9.7	
	3121	12.75	11.34	19	89.6	58.0	79	37.4	
	6330	19.52	16.03	30	90.9	62.7	125	4.1	
	4459	15.59	13.81	24	92.2	61.3	101	24.4	
	7843	27.79	13.80	27	90.4	62.6	113	0.2	
	6912	27.79	12.10	21	91.4	108.6	87	21.8	
<u>S x V x H</u> 1 x 1 x 1 1 x 1 x 2 1 x 2 x 1 1 x 2 x 2 1 x 3 x 1 1 x 3 x 2 2 x 1 x 1 2 x 1 x 2 2 x 2 x 1 2 x 2 x 2 2 x 3 x 1 2 x 3 x 2	2623	9.41	13.81	24	86.9	61.6	98	18.5	
	853	4.14	10.85	11	86.4	71.4	45	56.6	
	3364	12.28	14.24	26	88.0	62.5	106	6.5	
	2903	11.03	12.90	22	90.5	79.3	91	30.7	
	6082	23.10	12.96	24	89.2	62.4	100	0.8	
	3891	18.15	10.68	13	92.0	118.8	55	31.3	
	8734	29.06	15.07	35	91.6	62.5	145	0.0	
	6250	23.38	13.02	27	91.2	49.3	113	20.3	
	7874	23.70	16.60	36	92.1	62.8	148	0.0	
	7257	23.63	15.08	32	93.5	48.0	133	13.7	
	10033	33.53	14.80	29	90.7	62.5	121	0.0	
	9581	34.04	14.05	30	91.9	95.4	124	11.5	

(cont.)

Treatment	Acre Yield		Harvest Count	Clean Beets	NO3-N	Beets/100'	Root Rot
	Sugar Lbs	Beets Tons					
			No.	%	Mean	No.	%
S x V x H (cont.)							
3 x 1 x 1	4313	15.74	27	90.7	62.0	111	6.3
3 x 1 x 2	1162	6.10	12	90.1	58.8	50	53.3
3 x 2 x 1	7873	23.84	28	92.0	63.1	116	5.9
3 x 2 x 2	2777	10.68	18	92.6	63.8	73	34.6
3 x 3 x 1	7590	28.59	25	90.6	62.3	102	0.0
3 x 3 x 2	6438	28.07	16	91.2	138.5	66	27.9
4 x 1 x 1	4871	17.14	29	90.2	62.4	122	14.0
4 x 1 x 2	4219	17.38	26	90.8	52.5	108	19.4
4 x 2 x 1	6208	18.26	32	91.6	62.5	131	4.0
4 x 2 x 2	4898	17.02	26	92.0	54.4	107	18.5
4 x 3 x 1	7666	25.94	31	91.2	63.3	127	0.0
4 x 3 x 2	7737	30.89	25	90.7	81.6	104	16.5
Grand Mean							
C.V. (%)	5633.3	20.21	25.0	90.7	69.2	104.0	16.3
LSD (.05)	19.5	18.54	22.3	1.8	44.3	22.3	67.0
LSD (.05)	991.9	3.13	2.8	1.2	15.3	11.8	5.5
LSD (.05)	859.0	2.71	2.4	1.1	13.2	10.2	4.8
LSD (.05)	**	**	**	*	*	**	**
LSD (.05)	1718.0	5.41	4.9	2.1	26.5	20.4	9.6
LSD (.05)	908.6	3.10	4.6	1.3	25.4	19.2	9.0
LSD (.05)	786.9	2.69	4.0	1.2	22.0	16.6	7.8
LSD (.05)	1574.0	5.37	8.0	2.3	44.0	33.3	15.6
F value	36.5**	32.02**	32.9**	9.3**	1.8NS	32.9**	16.3**
F value	30.1**	50.11**	5.1*	6.2**	9.5**	5.1*	15.4**
F value	51.4**	15.44**	39.6**	4.4*	4.6*	39.6**	108.8**
F value	0.8NS	1.65NS	0.6NS	1.7NS	0.4NS	0.6NS	1.7NS
F value	5.8**	6.22**	2.5NS	1.1NS	1.4NS	2.5NS	6.3**
F value	2.3NS	4.05*	1.1NS	1.8NS	6.7**	1.1NS	1.1NS
F value	2.8*	1.96NS	0.7NS	0.7NS	0.3NS	0.7NS	0.9NS



TEST 5496. COMBINED RESISTANCE TO RHIZOMANIA AND CERCOSPORA LEAF SPOT, FIELD C,  
SALINAS, CA., 1996

12 entries x 8 replications, RCB  
1-row plots, 12 ft. long

Planted: June 3, 1996  
Harvested: December 2, 1996

Variety	Description	Acre Yield		Beets/ 100'	Bolting %	RJAP %	CLS Score <sup>1</sup>
		Sugar Lbs	Beets Tons				
US H11	L113401, 11-16-94	1676	8.14	181	0.0	74.7	5.8
Rizor	LF291, 2-13-96	3809	14.01	162	0.0	74.8	6.6
R409	CR-RZM R209-#(C)	3553	15.13	153	0.0	74.2	3.8
R410	CR-RZM R210-#(C)	3569	14.80	153	0.0	77.4	4.5
R105	RZM R005 (Rovigo line)	2498	9.26	132	0.0	74.8	6.0
R107	RZM R007	3359	14.12	168	0.0	74.7	5.8
R106	RZM R006 (Rovigo line)	1957	7.80	150	0.0	75.6	6.1
R108	RZM R008	3161	13.19	119	0.0	74.9	5.0
4006R	Betaseed, 2-8-96	3736	13.50	163	0.0	78.8	6.3
Monodoro	Hilleshog, 1992	2889	12.94	142	0.0	75.4	5.8
R522(Sp)	RZM-8S R322R4,... (C51)	3707	16.81	177	1.6	70.6	5.3
R526	RZM R426, F <sub>2</sub> (C37 x Bm)	1665	7.93	163	2.6	69.7	4.6
Mean		2964.9	12.30	155.3	0.3	74.6	5.4
LSD (.05)		557.3	2.04	22.9	1.9	1.8	0.9
C.V. (%)		18.9	16.64	14.8	536.8	2.5	16.1
F value		17.1**	18.98**	4.9**	1.6NS	14.6**	7.4**

<sup>1</sup> Cercospora leaf spot score 11-25-96 on a scale of 0 to 9 where 9 = complete defoliation.

NOTE: Infection with Cb from natural infection and inoculated 29 August 1996. See 1995 Sugarbeet Research Report, pages A20-21 and A55 (test 6495). Reselections for CR-Rz from R409 & R410 were released as CR09 & CR10 in 1996.

**TEST 496. BOLTING EVALUATION/SELECTION, 1995-96**

30 entries x 1 replication  
In rows up to 640 ft.

Planted: November 14, 1995  
Selected: December 4, 1996

Variety	Description	Beets/ 100'	% Bolting		
		No.	07/09	08/16	09/16
<u>Multigerm, O.P. Lines</u>					
R581(Sp)	RZM R481-43,-89 (C82)	867	6.6	12.7	12.7
R576	NB-ER-RZM R376,Y (C31Rz)	1064	0.0	0.1	0.2
R578(Sp)	RZM R478NB (C78)	1491	0.5	1.5	1.5
R580	NB-ER-RZM R380,Y	746	0.1	0.4	0.5
R580NB	RZM R480NB (C80NB)	787	0.1	0.1	0.6
R580%	RZM-%S R380(Sp)	874	1.1	3.2	3.2
R570	NB-ER-RZM R370	824	0.1	0.6	0.6
<u>Multigerm, O.P. Lines with WB GP</u>					
R551	U86-37rr x RZM-%S R40(C) (C79-#s)	828	2.3	5.1	5.1
Y564(Sp)	RZM 4205,P;... (25% Bm)	936	8.1	17.4	19.2
Y566	Y-#rr(C1) x RZM 4205,P (12% Bm)	788	1.3	4.4	4.4
Y567	Y-#rr(C2) x RZM 4205,P (12% Bm)	870	2.3	4.6	4.6
<u>Multigerm,S<sup>f</sup>S<sup>f</sup>,Aa Crosses</u>					
R581H18	RZM 4918aa x RZM R481-43,-89(C82)	820	3.9	5.9	5.9
R576-89-18H9	4911-4-#M(C)aa x R476-89-18	429	0.7	2.8	2.8
R576-89-18H19	4918-#(C)aa x R476-89-18(C76-89-18)	431	1.6	0.9	1.2
R578H16	4915-#(C)aa x RZM R478NB (C78)	587	1.0	1.0	1.0
R578H19	4918-#(C)aa x RZM R478NB (C78)	431	0.7	2.8	2.8
<u>Multigerm,S<sup>f</sup>,A:aa Populations</u>					
5915	RZM 4911,15,16,18aa x A(C)	1684	1.5	3.0	3.6
5925	S <sub>1</sub> (MM,S <sup>f</sup> ,Aa)aa x A	1570	0.2	0.2	0.2
5924	RZM 4918aa x Y#C1,C2	860	2.3	3.8	3.8
5911-4mA	RZM 4911-4mmA(tagged) (C911-4)	809	0.1	0.1	0.2
<u>Mm,S<sup>f</sup>,A:aa Cross</u>					
5911-4H87	4890mmaa (C890) x RZM 4911-4mmA	864	0.1	0.5	0.5
<u>Multigerm,S<sup>f</sup>,A:aa Popns with WB GP</u>					
5920	RZM 4287, (918aa x RZM 3287(R22))	879	0.1	0.5	1.0
5921(Sp)	RZM R422R4H15,17;Y3H15	886	12.0	20.4	20.4
5921H18	4918aa x RZM R422R4H15,17;Y3H15	910	4.8	7.9	8.2
5923	4918aa (C918) x RZM R40(C)	869	1.4	3.3	3.7
<u>Monoqerm,S<sup>f</sup>,A:aa Popns</u>					
5810	0790mmaa (C790) x 4265-4279(C890-#s)	1726	0.1	0.2	0.3
5869	3867-#(C)mmaa x 3890-#(C) (C890-1)	788	2.0	3.2	3.2
5834	RZM 4834	841	0.6	1.4	2.3
5893	RZM 4893	864	15.0	22.0	22.0
5895	RZM 4895,4833	734	3.4	6.8	8.4

**NOTES:** 4911-4-#(C) = S<sub>1</sub> composite from C911-4. 4918-#(C) = S<sub>1</sub> composite from C918. See footnotes for Test B296. Planted into rhizomania infested soil. Only lines 5920, 5810, 5869, 5834, 5893, & 5895 selected for NB, resistance to rzm, %S, root size, and root shape.

TEST 196. BOLTING EVALUATION OF LINES, SALINAS, CA., 1995-96

160 entries x 3 replications  
1-row plots, 22 ft. long

Planted: November 14, 1995  
Not harvested for yield

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew		
			07/09	08/16	09/16	08/07	08/16	Mean
MM,O.P.								
SP76222-0	L80466(8/87)(pollinator of USH20)	117	55.2	69.7	74.7	5.7	7.0	6.3
268	Inc. 768 (US 75)	108	0.0	1.2	1.2	5.0	5.7	5.3
U86-37	C37, 86443	111	0.0	0.0	0.0	4.7	6.3	5.5
U86-46/2	C46/2, 86342	105	0.0	0.0	1.5	3.3	5.3	4.3
R478NB	NB R278,Y (C78)	108	4.5	7.4	10.4	4.3	6.7	5.5
R578(Sp)	RZM R478NB (C78)	97	0.0	0.0	0.0	4.0	5.7	4.8
R578%	RZM-%S R378(Sp)	106	4.7	10.9	10.9	4.0	6.3	5.2
R578/2	NB-ER-RZM R378,Y (C78/2)	115	0.0	1.4	1.4	3.7	5.3	4.5
R578H11	4911-4#M(C)aa x RZM R478NB (C78)	103	0.0	5.8	5.8	4.0	6.0	5.0
R578H16	4915-#(C)aa x RZM R478NB	108	1.4	2.8	2.8	3.7	5.7	4.7
R578H18	4918(Sp)aa x RZM R478NB	96	0.0	0.0	0.0	3.3	5.7	4.5
R578H19	4918-#(C)aa x RZM R478NB	91	1.8	3.4	3.4	3.0	5.7	4.3
R539	NB-ER-RZM R137C7 (C39R)	96	5.9	16.3	16.3	4.3	5.7	5.0
R139C7	RZM R039C6 (C39R)	102	4.9	9.7	10.9	4.0	5.7	4.8
R547	NB-ER-RZM R147C7 (C47R)	106	0.0	2.5	3.7	4.0	5.7	4.8
R147C7	RZM R047C6 (C47R)	115	0.0	5.2	7.6	5.0	6.3	5.7
R570	NB-ER-RZM R370	99	1.4	1.4	1.4	4.3	6.0	5.2
R480NB	NB R280,Y	112	0.0	0.0	0.0	3.7	5.7	4.7
R580NB	RZM R480NB (C80NB)	115	0.0	0.0	0.0	3.7	6.0	4.8
R580	NB-ER-RZM R380,Y	109	0.0	0.0	0.0	3.3	6.0	4.7
R580%	RZM-%S R380(Sp)	115	2.5	2.5	2.5	4.3	5.7	5.0
R580-#	RZM R480-# (C80)	120	0.0	0.0	0.0	4.7	6.3	5.5
R580-45	RZM R480-45 (C80-45)	106	0.0	0.0	1.3	3.7	5.7	4.7
U86-37	C37, 86443	89	0.0	1.4	1.4	5.0	6.3	5.7
F86-31/6	C31/6, 86263	99	0.0	1.7	1.7	4.0	5.7	4.8
R576	NB-ER-RZM R376,Y	99	0.0	0.0	0.0	5.0	6.7	5.8
R581-43	NB-ER-RZM R381-43	114	1.2	1.2	2.4	3.7	5.7	4.7
R576-89	NB-ER-RZM R381-89,RZM R476-89-#	108	4.3	6.8	6.8	5.0	7.0	6.0

TEST 196. BOLTING EVALUATION OF LINES, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew		
			No.	07/09	08/16	09/16	08/07	08/16
MM,O.P. (cont.)								
R581(Sp)	RZM R481-43,-89 (C82)	93	8.9	17.9	19.3	4.0	5.7	4.8
R482NB	NB R276-43,-89 (C82)	100	1.4	2.6	4.0	3.0	5.3	4.2
R484	RZM R384	93	2.4	2.4	2.4	3.7	5.7	4.7
R543R2	RZM R443	102	23.8	27.3	29.1	5.0	7.0	6.0
R476-43-14	RZM R376-43-14 (C76-43-14)	100	0.0	0.0	0.0	4.3	5.7	5.0
R576-43-14	RZM R476-43-14 (C76-43-14)	109	1.4	4.3	5.7	5.3	6.3	5.8
R476-43-15	RZM R376-43-15 (C76-43-15)	89	0.0	0.0	0.0	3.0	5.0	4.0
R576-43-15	RZM R476-43-15 (C76-43-15)	103	1.6	1.6	1.6	3.3	4.7	4.0
R476-89-5	RZM R376-89-5 (C76-89-5)	109	0.0	2.8	2.8	4.3	5.3	4.8
R576-89-5	RZM R476-89-5 (C76-89-5)	111	0.0	2.6	2.6	3.7	5.0	4.3
R576-89-5NB	NB-ER-RZM R376-89-5 (C76-89-5)	103	1.2	4.2	4.2	4.0	4.7	4.3
R476-89-18	RZM R376-89-18 (C76-89-18)	105	1.4	1.4	1.4	3.3	5.0	4.2
R576-89-18	RZM R476-89-18 (C76-89-18)	88	0.0	1.4	1.4	4.0	6.0	5.0
R576-89-18NB	NB-ER-RZM R376-89-18 (C76-89-18)	102	1.3	1.3	1.3	3.3	5.3	4.3
R576-89-18(Sp)	Inc. R476-89-18 (C76-89-18)	85	3.1	3.1	3.1	3.7	5.7	4.7
R576-89-18H9	4911-4#M(C)aa x R476-89-18	100	1.4	5.9	7.4	4.0	5.3	4.7
R576-89-18H18	RZM 4918aa x R476-89-18	103	4.1	6.0	6.0	4.0	5.3	4.7
R576-89-18H19	4918-#(C)aa x R476-89-18	96	0.0	2.5	2.5	3.0	5.3	4.2
R581H11	4911-4m,aa x RZM R481-43,-89(C82)	112	1.3	4.0	4.0	3.3	5.7	4.5
R581H18	RZM 4918aa x RZM R481-43,-89	96	3.6	4.9	7.1	3.3	6.0	4.7
Y562	RZM Y462R, Y#rr(C) x R#(C)R	105	7.5	8.7	10.2	4.7	6.7	5.7
Y563	RZM Y463, Y#R(C) x R#(C)R	118	3.7	4.9	6.2	3.7	5.7	4.7
Y568	Y-#rr(C1) x RZM Y462,R463,R#(C)	112	0.0	0.0	1.5	3.7	6.3	5.0
Y569	Y-#rr(C2) x RZM Y462,R463,R#(C)	103	6.1	8.9	13.6	3.3	5.3	4.3
Y570	RZM Y462rr x RZM Y462,R463,R#(C)	111	6.5	15.9	18.9	4.3	5.7	5.0
F86-31/6	C31/6, 86263	100	0.0	0.0	0.0	4.0	5.0	4.5
SP7622-O	L80466 (8/87)	100	39.2	51.3	52.7	5.3	7.0	6.2
U86-37	C37, 86443	93	0.0	0.0	0.0	5.0	5.7	5.3

TEST 196. BOLTING EVALUATION OF LINES, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100' No.	% Bolting		Powdery Mildew			
			07/09	08/16	08/07	08/16	Mean	
MM,O.P. (cont.)								
R479 (Sp)	Inc. Inc. R379	97	12.6	18.8	23.5	5.3	6.7	6.0
R479 (Iso)	RZM R379; C79-1(Rz)	103	2.7	11.2	13.9	5.0	6.3	5.7
R579	RZM R479(Iso), C79-1(Rz)	96	3.0	3.0	3.0	4.3	6.7	5.5
R524	RZM R424, C79-2 (WB41)	103	2.8	11.6	11.6	4.7	6.7	5.7
R525	RZM R425, C79-3 (WB42)	106	1.3	2.8	2.8	5.0	6.3	5.7
R528	RZM R428, C79-4 (PI07)	109	2.6	2.6	2.6	5.7	6.3	6.0
R532	RZM R432, C79-5 (R04)	100	0.0	3.5	3.5	5.0	7.3	6.2
R534	RZM R434, C79-6 (R05)	115	0.0	0.0	0.0	5.0	7.0	6.0
R535	RZM R435, C79-7 (SES)	103	1.8	3.0	4.2	5.0	6.0	5.5
R536	RZM R436, C79-8 (R22)	124	2.5	8.5	8.5	6.3	7.0	6.7
R537	RZM R437, C79-9 (WB151)	115	1.3	2.8	4.0	4.0	6.0	5.0
R541	RZM R441, C79-10 (WB169)	114	1.2	12.0	13.3	5.3	7.0	6.2
R542	RZM R442, C79-11 (WB258)	94	2.9	7.8	9.2	4.7	5.7	5.2
R545	RZM 4201, (R04)	86	0.0	0.0	0.0	5.0	5.7	5.3
R546	RZM 4243, (R22)	99	1.4	3.2	3.2	5.7	6.3	6.0
R548	RZM 4248, (WB169)	115	0.0	1.5	1.5	5.3	6.0	5.7
R549	RZM 4249, (WB258)	106	8.2	13.9	13.9	5.7	7.3	6.5
R550	RZM 4247, (WB151)	114	0.0	0.0	0.0	4.0	6.0	5.0
U86-37	C37, 86443	85	3.0	3.0	3.0	5.0	6.3	5.7
R540-1	RZM R440-1R, Inc.(C37 x C79-#s)	106	1.6	12.7	12.7	5.0	7.0	6.0
R551	U86-37 x RZM R40(C) (C79-#s)	89	3.1	12.0	12.0	4.7	7.0	5.8
R526	RZM R426R, F <sub>2</sub> (C37 x Bm)	103	70.1	82.0	83.8	6.3	7.7	7.0
R540% (Iso)	RZM-8S 3201-3285, Inc.(C37xC79-#s)	100	1.5	4.5	4.5	5.7	7.3	6.5
R540 (Sp)	RZM-8S 3201-3285	106	12.1	14.4	14.4	4.7	6.7	5.7
Y564 (Iso)	RZM 4205,P; 4206,P;...(25% Bm)	109	10.0	21.0	22.4	4.7	7.3	6.0
Y564 (Sp)	RZM 4205,P; 4206,P;...(25% Bm)	112	9.9	22.4	22.4	4.3	7.0	5.7
Y565	RZM 4280,P; 4284,P (6% Bm)	106	1.2	4.3	4.3	4.3	6.7	5.5
Y566	Y-#rr(C1) x RZM 4205,P;...(12% Bm)	103	0.0	0.0	3.0	3.3	5.3	4.3

TEST 196. BOLTING EVALUATION OF LINES, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew		
		No.	07/09	08/16	09/16	08/07	08/16	Mean
MM,O.P. (cont.)								
Y567	Y-#rr(C2) x RZM 4205,P;...(12% Bm)	112	2.5	3.7	3.7	3.7	4.7	4.2
Y522Y4	RZM-%S R322Y3,Y37	112	16.4	22.1	27.4	4.3	6.3	5.3
R522R5	RZM-%S R322R4,R4%	108	36.8	53.6	60.6	5.0	7.7	6.3
R522(Sp)	RZM-%S R322R4,... (C51)	124	47.6	65.8	69.6	5.3	7.7	6.5
MM,S',A:aa Popns								
R522H18	4918aa x RZM-%S R322R4,... (C51)	99	13.3	20.8	25.1	5.3	7.7	6.5
5920	RZM 4287 (6% Bm)	120	0.0	1.2	1.2	4.3	6.3	5.3
5921 (Iso)	RZM R422R4H15,H17,...(25% Bm)	112	6.7	16.2	18.8	5.0	7.0	6.0
5921 (Sp)	RZM R422R4H15,H17,...(25% Bm)	114	23.4	32.5	39.0	4.7	7.3	6.0
5921H18	4918aa x RZM R422R4H15,H17,..(12%Bm)	106	6.1	11.7	13.0	4.7	6.0	5.3
5922	RZM R440H18	109	6.2	6.2	6.2	5.0	5.7	5.3
5923	4918aa x RZM R40(C)	102	0.0	0.0	1.8	4.3	6.3	5.3
R544R2	RZM R444	109	5.4	12.4	12.4	5.0	7.0	6.0
5911-4 (Iso)	NB-ER-RZM 3911-4 (C911-4)	120	0.0	0.0	0.0	3.0	4.7	3.8
5911-4m	RZM 4911-4mmaa x A (C911-4m)	114	0.0	0.0	0.0	3.3	5.0	4.2
5911-4mA	RZM 4911-4mma (tagged) (C911-4m)	96	0.0	0.0	0.0	3.0	5.0	4.0
5911-4M	RZM 4911-4Maa x A (C911-4M)	120	0.0	0.0	0.0	3.3	5.0	4.2
5911-4MA	RZM 4911-4MA (C911-4M)	93	0.0	0.0	0.0	4.3	5.0	4.7
5911-4-7	T-O Sel. 4911-4-7	61	0.0	0.0	0.0	3.0	4.0	3.5
5911-4-7CMS	4911-4H50 x T-O Sel. 4911-4-7	100	0.0	0.0	0.0	3.3	4.3	3.8
5913-70	RZM 3913-70 (C913-70)	100	0.0	0.0	0.0	3.0	4.7	3.8
5913-71	RZM 4913-71	80	0.0	0.0	0.0	3.3	5.7	4.5
4915NB	NB 2915 (Sp)	105	0.0	0.0	0.0	3.7	6.3	5.0
4915 (Sp)	RZM 3915aa x A	108	1.3	8.0	8.0	3.3	5.3	4.3
4918	RZM 3918aa x A (C918)	111	2.6	2.6	2.6	3.3	5.3	4.3
5915% (Iso)	RZM-%S 3915(Sp)(A,aa)	96	4.4	4.4	4.4	3.3	5.3	4.3
5915 (Sp)	RZM 4911,4915,4916,4918aa x A	109	2.7	3.9	3.9	4.0	5.7	4.8
5915(C)	(C)RZM MM,A:aa,Rzaa x A	103	1.7	5.5	5.5	3.7	6.0	4.8
5915(C)A	(C)RZM MM,A:aa,RzA	103	1.2	3.7	4.9	3.3	5.7	4.5

TEST 196. BOLTING EVALUATION OF LINES, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew			
			No.	07/09	08/16	09/16	08/07	08/16	Mean
<u>MM,S',A:aa Popns (cont.)</u>									
5924	RZM 4918aa x Y-#rr C1,C2,...	106	3.1	5.6	10.3	4.0	5.0	4.5	
5925	S <sub>1</sub> (MM,A:aa,Rz)(C)aa x A	112	0.0	1.3	1.3	3.3	5.3	4.3	
5925-15	RZM 4915-#S <sub>1</sub> (C)aa x A	114	1.9	1.9	1.9	4.0	6.0	5.0	
5925-15A	RZM 4915-#S <sub>1</sub> (C)A	91	1.3	5.3	5.3	3.0	5.0	4.0	
5925-18	RZM 4918-#S <sub>1</sub> (C)aa x A	115	0.0	2.5	2.5	3.7	5.0	4.3	
5925-18A	RZM 4918-#S <sub>1</sub> (C)A	86	0.0	1.9	1.9	4.0	5.3	4.7	
N523	NR-RZM N421,N422,N423,N424	97	0.0	1.9	3.7	3.3	5.7	4.5	
N525	NR-RZM N427,N428	100	1.3	1.3	1.3	3.7	5.0	4.3	
<u>Monogerm,S',A:aa Popns</u>									
5867(T-O)	T-O-Sel. 4867-#'s	115	1.6	3.2	3.2	5.0	6.3	5.7	
5867HO	3867HO x T-O-Sel. 4867-#'s	124	9.9	17.2	19.8	6.0	7.3	6.7	
5867NB	Inc. 3867-3,4,5,7,8	100	1.4	7.1	8.6	5.0	6.7	5.8	
5867NBHO	3867HO x Inc. 3867-3,4,5,7,8	109	9.5	24.7	27.4	5.3	7.3	6.3	
5869	3867-#(C)mmaa x 3890-#(C) (C890-1)	111	0.0	2.7	2.7	5.0	6.3	5.7	
5869HO	3867HO x 3890-#(C) (C890-1)	127	4.8	6.0	7.1	5.7	6.7	6.2	
5890	3890-#S <sub>1</sub> (C)mmaa x A, (C890-1)	115	0.0	0.0	0.0	4.3	5.7	5.0	
5890HO	4890HO x 3890-#S <sub>1</sub> (C)mmaa x A	126	0.0	0.0	0.0	3.3	6.0	4.7	
5890A	Inc. 3890-#S <sub>1</sub> (C)mma	94	1.7	1.7	1.7	4.3	5.7	5.0	
5810	0790mmaa x 4265-4279(C) (C890-#s)	118	0.0	0.0	0.0	5.0	6.7	5.8	
5810HO	0790HO x 4265-4279(C)	115	2.5	3.8	3.8	4.0	6.3	5.2	
5811	4890mmaa x 4265-4279(C)	123	0.0	0.0	0.0	3.3	6.3	4.8	
5811HO	4890HO x 4265-4279(C)	118	0.0	0.0	0.0	5.0	6.3	5.7	
5822m	4265-4279mmaa x A (C890-#s)	123	0.0	0.0	0.0	4.0	6.0	5.0	
5822mA	Inc. 4265-4279mMA (C890-#s)	114	0.0	4.4	4.4	4.3	6.3	5.3	
5822M	4265-4279Maa x A (C890-#s)	120	0.0	1.1	1.1	4.0	6.0	5.0	

TEST 196. BOLTING EVALUATION OF LINES, SALINAS, CA., 1995-96  
(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		
			No.	07/02	08/16	09/16	08/07	08/16	Mean
Monogerm, S', A:aa Popns (cont.)									
5822MA	Inc. 4265-4279MA (C890-#s)	103		0.0	1.4	2.8	4.7	6.3	5.5
5812	RZM 4275, (WB41,42) (C890-2/3)	117		0.0	5.6	5.6	5.3	6.7	6.0
5814	RZM 4267, (PI07) (C890-4)	121		0.0	0.0	0.0	4.3	6.7	5.5
5815	RZM 4265, (R04) (C890-5)	108		0.0	2.7	2.7	4.0	6.0	5.0
5817	RZM 4268,77,P,(SES,R05) (C890-6/7)	105		0.0	0.0	0.0	4.7	6.0	5.3
5818	RZM 4270,72, (R22) (C890-8)	120		1.6	2.7	2.7	5.0	6.3	5.7
5819	RZM 4273 (WB151) (C890-9)	102		0.0	0.0	0.0	4.3	6.7	5.5
5820	RZM 4278,79,P,(WB169,258) (C890-10/11)	121		0.0	3.7	6.0	4.3	6.0	5.2
5834	RZM 4834	112		1.3	11.0	13.7	4.3	6.3	5.3
5893	RZM 4893 (A,aa)	111		28.8	39.7	39.7	5.0	7.0	6.0
5895	RZM 4895, 4833	124		2.5	5.0	6.3	4.3	6.7	5.5
5859%	RZM-% 3859m(Sp) (C859)	126		1.2	1.2	1.2	3.7	6.0	4.8
5864-8	T-O-Sel. 4864-8-#	105		57.7	71.7	73.1	4.7	6.0	5.3
5864-14	T-O-Sel. 4864-14-#	62		1.6	4.8	7.9	4.3	5.7	5.0
5864-34	T-O-Sel. 4864-34-#	86		0.0	0.0	0.0	3.3	5.0	4.2
F92-790-15	Inc. C790-15 (921194)	105		0.0	0.0	0.0	3.0	5.3	4.2
F92-790-15CMS	CMS x Inc. C790-15 (921190)	112		0.0	0.0	0.0	3.7	5.7	4.7
5790-15	Inc. 4790-15	102		0.0	0.0	0.0	3.0	4.7	3.8
5790-15CMS	C790-15CMS x Inc. 4790-15	118		0.0	0.0	0.0	3.3	5.0	4.2
5790-15-21	Inc. 4790-15-21	30		0.0	0.0	0.0	2.7	4.3	3.5
5790-15-21CMS	4790-15-21CMS x Inc. 4790-15-21	41		0.0	2.6	2.6	4.0	5.0	4.5
5790-15-23	Inc. 4790-15-23	15		0.0	0.0	0.0	3.0	4.3	3.7
5790-15-23CMS	4790-15-23CMS x Inc. 4790-15-23	58		0.0	0.0	2.6	3.0	4.7	3.8
R578 (Sp)	RZM R478NB (C78)	91		1.5	1.5	3.2	3.3	5.7	4.5
Mean		104.0		4.2	7.1	7.9	4.2	6.0	5.1
LSD (.05)		25.4		7.3	9.9	10.9	1.1	1.0	0.8
C.V. (%)		15.2		107.0	86.0	85.6	15.8	10.2	10.3
F value		2.9**		16.0**	14.6**	13.4**	4.4**	4.9**	6.0**

NOTES: See footnotes for Test 296.



TEST 296. BOLTING EVALUATION OF HYBRIDS, SALINAS, CA., 1995-96

120 entries x 3 replications  
1-row plots, 22 ft. long

Planted: November 14, 1995  
Not harvested for yield

Variety	Description	Beets/ 100'	% Bolting			Powdery Mildew		
			07/09	08/16	09/16	08/09	08/16	Mean
US H11	L113401, 11-16-94	137	1.1	1.1	1.1	5.0	6.7	5.8
WS-PM9	HM-WS PM9 (4-18-95)	140	12.8	17.1	18.1	4.7	6.3	5.5
SS-NB3	8-94, Spreckels	123	0.0	0.0	0.0	4.3	6.3	5.3
Rhizoguard	8-30-94, L892301 Holly	112	2.4	6.9	6.9	4.7	6.3	5.5
SS-IV3	8-21-95 Spreckels	124	4.5	9.5	9.5	5.0	7.0	6.0
Rizor	RZ3/1022, 1993 SES	124	3.7	11.0	12.3	5.3	7.0	6.2
Rival	HH103, L 1031203 (8-29-95)	132	19.6	40.4	49.2	6.0	7.3	6.7
4006	4006.5103 (8-28-95) BTS	126	0.0	0.0	0.0	5.0	6.3	5.7
SS-781R	941000, 8-21-95 Spreckels	130	0.0	0.0	0.0	4.3	5.7	5.0
SS-NB2R2	1993 seed, 8-28-95 Spreckels	137	0.0	1.2	2.5	5.0	6.7	5.8
SS-NB2R2	1994 seed, 8-28-95 Spreckels	124	0.0	0.0	0.0	5.0	6.7	5.8
SS-NB2R2	1995 seed, 8-28-95 Spreckels	123	1.2	2.4	3.6	5.7	7.3	6.5
R578H3	F82-562HO x RZM R478NB (C78)	120	0.0	0.0	0.0	4.7	6.7	5.7
R578H8	F82-546H3 x RZM R478NB	129	0.0	1.1	1.1	4.7	6.7	5.7
R578H20	U87-309H3 x RZM R478NB	135	3.0	3.0	3.0	5.0	7.7	6.3
R578H37	4807HO (C306CMS) x RZM R478NB	111	0.0	0.0	0.0	4.7	6.7	5.7
R578H39	91-762-17CMS x RZM R478NB	118	5.1	6.3	7.7	4.7	6.7	5.7
R578H50	F92-790-15CMS x RZM R478NB	132	0.0	3.6	3.6	4.0	6.0	5.0
R578H50-#	4790-15-#(C)CMS x RZM R478NB	112	4.4	8.4	8.4	4.7	6.7	5.7
R578H50-21	4790-15-21CMS x RZM R478NB	138	1.2	3.4	3.4	4.0	6.7	5.3
R578H50-23	4790-15-23CMS x RZM R478NB	108	2.6	4.9	4.9	4.7	6.7	5.7
R578H51	F92-790-15H26 x RZM R478NB	118	3.9	5.0	6.3	4.7	6.3	5.5
R578H52	F92-790-15H39 x RZM R478NB	109	3.9	5.0	5.0	4.0	5.7	4.8
R378H52	F92-790-15H39 x R278,Y	123	8.9	12.2	12.2	4.3	5.7	5.0
R378H8	F82-546H3 x R278,Y	130	2.4	6.1	6.1	5.0	7.0	6.0
R378H20	U87-309H3 x R278,Y	126	8.5	15.9	17.0	5.3	7.3	6.3
R378H50	F92-790-15CMS x R278,Y	114	3.8	5.2	5.2	3.7	6.0	4.8
R578H11	4911-4#M(C)aa x RZM R478NB (C78)	112	0.0	0.0	0.0	4.3	5.7	5.0

TEST 296. BOLTING EVALUATION OF HYBRIDS, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100' No.	% Bolting				Powdery Mildew	
			07/09	08/16	09/16	08/09	08/16	Mean
R578H12	4911-4H50 x RZM R478NB (C78)	100	1.4	1.4	1.4	4.0	6.0	5.0
R578H13	4918H50 x RZM R478NB	118	2.7	3.9	5.2	4.0	6.0	5.0
R578H16	4915-#(C)aa x RZM R478NB	86	1.4	3.5	3.5	4.0	6.3	5.2
R578H18	4915(Sp)aa x RZM R478NB	100	0.0	1.3	2.6	4.0	5.7	4.8
R578H19	4918-#(C)aa x RZM R478NB	97	0.0	0.0	0.0	3.7	5.3	4.5
R578H59	4859m,aa (C859) x RZM R478NB	117	1.1	1.1	1.1	4.3	6.3	5.3
US H11	L113401, 11-16-94	118	1.2	1.2	1.2	5.0	7.0	6.0
SS-NB3	8-94, Spreckels	115	0.0	0.0	0.0	4.7	6.3	5.5
R578H65	4865m,aa x RZM R478NB	105	4.5	7.9	7.9	5.0	7.0	6.0
R578H74	4859-2H50 x RZM R478NB	130	1.0	1.0	2.1	3.7	5.7	4.7
R578H75	4865-4H50 x RZM R478NB	115	3.4	4.8	6.2	4.3	6.7	5.5
R578H76	4867-1H50 x RZM R478NB	100	1.3	1.3	1.3	4.0	6.0	5.0
R578H77	4891-4H50 x RZM R478NB	105	4.5	9.1	9.1	4.3	6.3	5.3
R578H78	4864-8H50 x RZM R478NB	117	1.2	4.9	6.5	4.0	6.0	5.0
R578H79	4864-14H50 x RZM R478NB	117	0.0	1.6	1.6	4.0	6.0	5.0
R578H80	4864-34H50 x RZM R478NB	111	6.7	7.9	9.5	5.0	6.7	5.8
R578H87	4890m,aa (C890) x RZM R478NB	105	1.6	3.3	4.4	4.7	6.3	5.5
R578H93	4893aa x RZM R478NB	123	12.1	17.3	17.3	5.3	7.0	6.2
R578H94	4894aa x RZM R478NB	100	1.4	1.4	1.4	5.0	6.3	5.7
R578H8	F82-546H3 x RZM R478NB	117	0.0	1.2	2.4	4.7	6.7	5.7
R581H50	F92-790-15CMSxRZM R481-43,-89 (C82)	115	5.6	8.3	8.3	3.3	5.7	4.5
R581H51	F92-790-15H26 x RZM R481-43,-89	115	4.6	11.4	11.4	4.0	6.0	5.0
R581H52	F92-790-15H39 x RZM R481-43,-89	117	3.9	6.2	6.2	3.0	5.0	4.0
R581H87	RZM 4890m,aa (C890)xRZM R481-43,-89	102	1.4	2.7	2.7	3.7	6.3	5.0
R581H10	4911-4H90 x RZM R481-43,-89	121	1.2	2.4	2.4	3.0	6.0	4.5
R581H11	4911-4m,aa x RZM R481-43,-89	115	5.2	8.9	10.2	3.3	5.7	4.5
R581H12	4911-4H50 x RZM R481-43,-89	123	0.0	2.4	3.7	4.0	5.7	4.8
R581H13	4918H50 x RZM R481-43,-89	112	5.3	12.0	12.0	4.0	5.7	4.8

TEST 296. BOLTING EVALUATION OF HYBRIDS, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100'	% Bolting		Powdery Mildew	
			07/09	08/16	08/09	08/16
No.						Mean
R581H18	RZM 4918aa x RZM R481-43,-89(C82)	115	2.9	2.9	3.3	5.7
R581H59	RZM 4859m,aa x RZM R481-43,-89	108	5.6	7.2	4.3	6.3
R581H65	RZM 4865m,aa x RZM R481-43,-89	89	11.3	18.5	5.3	6.7
R581H65NB	RZM 4865NBaa x RZM R481-43,-89	96	4.9	8.0	4.3	6.7
R576-89-18H50	F92-790-15CMS x R476-89-18(C76-89-18)	106	1.3	2.8	3.3	4.7
R576-89-18H52	F92-790-15H39 x R476-89-18	118	0.0	0.0	3.3	5.0
R576-89-18H9	4911-4#M(C)aa x R476-89-18	96	0.0	0.0	3.0	5.0
R576-89-18H18	RZM 4918aa x R476-89-18	94	0.0	0.0	3.0	5.3
R576-89-18H19	4918-#(C)aa x R476-89-18	115	2.4	3.6	3.3	5.7
R576-89-18H65	4865m,aa x R476-89-18	124	1.3	1.3	4.0	6.0
R576-89-18H87	4890m,aa (C890) x R476-89-18	108	0.0	0.0	4.0	6.0
R576-43-14H50	F92-790-15CMS x RZM R476-43-14	106	5.7	5.7	4.3	6.3
R576-43-15H50	F92-790-15CMS x RZM R476-43-15	112	0.0	0.0	3.3	5.3
R576-89-5H50	F92-790-15CMS x RZM R476-89-5	109	0.0	0.0	3.7	5.7
R576-89-18H50(Iso)	F92-790-15CMS x RZM R476-89-18	102	0.0	1.3	3.7	5.7
5911-4H50(Iso)	F92-790-15CMS x NB-ER-RZM 3911-4	112	0.0	0.0	3.7	5.0
5911-4H50(Sp)	F92-790-15CMS x RZM 4911-4m(C911-4)	121	0.0	1.3	3.7	5.7
5911-4H87	4890m,aa x RZM 4911-4m	132	2.3	2.3	4.0	5.7
5913-70H50	F92-790-15CMS x RZM 3913-70(C913-70)	123	0.0	0.0	3.3	5.3
5913-71H50	F92-790-15CMS x RZM 4913-71	123	0.0	0.0	3.3	5.3
5915#H50	F92-790-15CMS x RZM-#S 3915(Sp)	120	0.0	0.0	3.3	5.0
5921H50	F92-790-15CMS x RZM R21(C)	121	5.1	7.6	4.7	6.7
5921H52	F92-790-15H39 x RZM R21(C)	108	2.8	6.9	4.7	6.3
5921H18	4918aa x RZM R21(C)	106	3.0	4.4	5.0	6.7
R540H50	F92-790-15CMS x RZM R40(C)	96	4.1	7.0	5.0	6.7
R540H52	F92-790-15H39 x RZM R40(C)	102	0.0	0.0	4.7	6.7
R540H87	4890m,aa x RZM R40(C)	97	1.9	1.9	4.7	6.3
US H11	L113401, 11-16-94	138	0.0	0.0	5.3	7.7

TEST 296. BOLTING EVALUATION OF HYBRIDS, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100'	% Bolting				Powdery Mildew		
			No.	07/09	08/16	09/16	08/09	08/16	Mean
SS-NB3	8-94 Spreckels	123		0.0	0.0	0.0	4.0	6.3	5.2
R522H50	F92-790-15CMS x RZM R22(C) (C51)	126		15.3	29.5	40.1	4.7	6.7	5.7
R522H52	F92-790-15H39 x RZM R22(C) (C51)	118		16.0	30.1	30.1	4.0	7.0	5.5
R522H18	4918aa x RZM R22(C) (C51)	118		2.4	10.6	13.4	4.7	7.0	5.8
R479H50(Sp)	F92-790-15CMS x R379 (C79-1)	120		10.5	17.3	17.3	5.0	6.3	5.7
R479H50(Iso)	F92-790-15CMS x RZM R379 (C79-1)	121		0.0	0.0	1.1	3.7	6.0	4.8
R579H50	F92-790-15CMS x RZM R479(Iso) (C79-1)	121		2.5	11.4	11.4	4.3	6.3	5.3
R524H50	F92-790-15CMS x RZM R424 (C79-2)	117		1.1	2.3	2.3	4.7	6.3	5.5
R525H50	F92-790-15CMS x RZM R425 (C79-3)	100		0.0	1.1	1.1	4.3	6.3	5.3
R528H50	F92-790-15CMS x RZM R428 (C79-4)	135		0.0	2.3	2.3	4.3	6.0	5.2
R532H50	F92-790-15CMS x RZM R432 (C79-5)	124		3.8	6.3	7.5	5.0	7.0	6.0
R534H50	F92-790-15CMS x RZM R434 (C79-6)	123		1.1	2.3	2.3	4.3	6.0	5.2
R535H50	F92-790-15CMS x RZM R435 (C79-7)	111		0.0	2.9	2.9	3.7	6.0	4.8
R536H50	F92-790-15CMS x RZM R436 (C79-8)	123		1.2	1.2	5.2	4.7	6.3	5.5
R537H50	F92-790-15CMS x RZM R437 (C79-9)	106		1.5	3.0	3.0	3.7	5.7	4.7
R541H50	F92-790-15CMS x RZM R441 (C79-10)	126		1.2	4.4	4.4	4.3	6.7	5.5
R542H50	F92-790-15CMS x RZM R442 (C79-11)	115		2.2	6.2	6.2	4.3	6.7	5.5
R543R2H50	F92-790-15CMS x RZM R443	133		3.6	13.5	13.5	4.7	6.7	5.7
R544R2H50	F92-790-15CMS x RZM R444	135		0.0	1.1	1.1	5.0	6.3	5.7
US H11	L113901, 11-16-94	124		0.0	0.0	0.0	6.0	7.0	6.5
SS-NB7R	L950840, 11-13-95 Spreckels	137		1.2	3.8	3.8	5.0	6.7	5.8
4454	4454.4002 Betaseed	140		0.0	5.2	6.3	4.3	6.3	5.3
HM 1815	3-28-95 Hilleshog	130		14.9	23.8	27.1	6.7	7.0	6.8
R479H8	F82-546H3 x R379 (C79-1)	126		2.6	6.2	6.2	5.0	7.0	6.0
4918H8	F82-546H3 x RZM 3918 (C918)	117		0.0	0.0	0.0	4.3	6.0	5.2
R578H8	F82-546H3 x RZM R478NB (C78)	143		2.2	3.2	5.6	4.0	6.7	5.3
R378H8	F82-546H3 x R278,Y	137		2.3	3.4	4.4	4.7	6.3	5.5
R480-45H8	F82-546H3 x R280-45 (C80-45)	120		1.4	2.8	2.8	4.0	6.0	5.0

TEST 296. BOLTING EVALUATION OF HYBRIDS, SALINAS, CA., 1995-96

(cont.)

Variety	Description	Beets/ 100'	% Bolting		Powdery Mildew		
			07/09	08/16	09/16	08/09	08/16
		No.					Mean
R578H50	F92-790-15CMS x RZM R478NB (C78)	117	0.0	0.0	1.5	4.0	6.0
R578H50-#	4790-15-#(C)CMS x RZM R478NB	112	5.9	8.7	8.7	4.3	6.3
R578H50-21	4790-15-21CMS x RZM R478NB	133	1.0	2.2	2.2	3.3	5.3
R578H50-23	4790-15-23CMS x RZM R478NB	105	0.0	0.0	0.0	4.0	6.3
R578(SP)	RZM R478NB (C78)	105	1.2	2.6	2.6	3.7	6.0
5911-4M	RZM 4911-4Maa x A, (C911-4)	106	0.0	0.0	0.0	3.7	5.3
5911-4H50(SP)	F92-790-15CMS x RZM 4911-4m	130	0.0	0.0	0.0	4.0	6.0
R576-89-18H50(SP)	F92-790-15CMS x R476-89-18	121	0.0	0.0	1.2	3.3	5.0
Mean							4.2
LSD (.05)		117.3	2.6	4.9	5.5	4.3	6.2
C.V. (%)		29.7	5.0	7.4	7.8	1.2	1.0
F value		15.7	117.8	93.5	88.0	17.4	10.1
		1.3NS	4.3**	6.2**	7.3**	2.5**	2.8**
							3.2**

NOTES: Test 196, 296 & 396 were planted to obtain information on relative bolting tendency. The winter of 1995-96 was very mild (a killing frost did not occur) and bolting induction was low. These tests should adequately separate easy, moderate, and nonbolting types but are not critical enough to separate high degrees of nonbolting tendency.

Several problems in addition to a very mild winter were encountered with tests 196, 296 and 396. Following thinning, some plants became stunted, leaves became necrotic, and death occurred. This appeared to be caused by a herbicide residue, but we were unable to determine if so or which type of herbicide. Secondly, a moderate infection with southern root rot, caused by Sclerocium rolfsii, occurred which reduced stands throughout the whole course of the season.

F92-790-15H26 = C309 x C790-15. F92-790-15H39 = C762-17 x C790-15. 4911-4H50 = C790-15CMS x C911-4. 4918 = C918. 4918-#(C) = S<sub>1</sub> composite from C918. 4911-4H90 = C890aa x C911-4.

TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

160 entries x 3 replications  
1-row plots, 18 ft. long

Planted: April 12, 1996  
Scored: October 18 & 23, 1996  
Inoc. Ecb: July 11, 1996

Variety	Description	Powdery Mildew					Harvest		Stand		Erwinia		
		08/19	09/04	09/18	09/30	Mean	Count	Mean	Count	Mean	DI	Rating	
MM,O.P. lines													
Block 1													
E840	Inc. E440, E640	4.0	4.3	5.0	5.7	4.8	21	26	26	98.7	0.0		
US H11	L113401, 11-16-94	3.7	3.7	6.0	7.7	4.9	20	27	27	16.8	64.3		
U86-46/2	C46/2, 86342	3.0	3.3	3.7	5.7	3.7	24	26	26	6.8	87.0		
R478NB	NB R278,Y (C78)	2.7	3.0	3.7	5.3	3.5	23	20	20	15.8	73.3		
R578(Sp)	RZM R478NB	2.3	3.0	4.0	6.7	3.8	26	27	27	6.4	83.3		
R578/2	NB-ER-RZM R378,Y (C78/2)	2.3	3.3	3.7	6.3	3.6	26	27	27	5.9	89.2		
R578%	RZM-%S R378(Sp)	2.7	3.7	4.3	6.3	3.9	26	27	27	18.2	73.5		
R578H11	4911-4#M(C)aa x RZM R478NB	2.7	3.3	4.7	6.3	4.0	22	27	27	15.5	73.0		
R139C7	RZM R039C6 (C39R)	3.0	3.0	3.3	5.3	3.6	24	26	26	19.0	68.7		
R539	NB-ER-RZM R137C7	2.7	3.7	3.7	5.3	3.6	20	22	22	16.0	75.7		
R147C7	RZM R047C6 (C47R)	3.7	4.0	4.3	6.7	4.4	26	26	26	13.7	78.8		
R547	NB-ER-RZM R147C7	3.3	4.0	5.0	6.7	4.4	26	26	26	3.5	93.5		
R480NB	NB R280,Y (C80NB)	3.0	3.7	4.3	6.0	4.1	23	24	24	14.7	80.1		
R580NB	RZM R480NB (C80NB)	3.0	3.0	4.3	6.7	4.0	26	27	27	23.3	66.8		
R580	NB-ER-RZM R380,Y	3.0	4.0	4.3	6.3	4.1	26	27	27	9.2	82.8		
R580%	RZM-%S R380(Sp)	4.3	4.0	5.0	7.0	4.8	25	26	26	15.2	78.4		
Block 2													
R580-#	RZM R480-# (C80)	3.3	4.0	4.0	5.7	4.1	27	27	27	12.9	78.8		
R580-45	RZM R480-45 (C80-45)	3.0	4.0	4.0	5.0	3.9	25	26	26	9.7	81.4		
R570	NB-ER-RZM R370	2.7	3.3	4.0	6.3	3.8	26	25	25	9.0	82.1		
F86-31/6	C31/6, 86263	2.7	3.7	4.3	5.7	3.9	22	22	22	11.9	79.3		
R576	NB-ER-RZM R376,Y (C31Rz)	3.0	3.0	4.7	6.7	4.1	26	26	26	11.2	81.8		
R581-43	NB-ER-RZM R381-43	2.7	3.3	4.3	6.3	3.9	26	26	26	13.1	76.8		
R576-89	NB-ER-RZM R381-89 & RZM R476-89-#	3.7	4.0	5.7	6.7	4.8	24	22	22	21.9	64.4		
E840	Inc. E440, E640	4.0	4.7	4.3	5.7	4.7	21	25	25	100.0	0.0		

TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew				Mean	Harvest		Stand	Erwinia	
		08/19	09/04	09/18	09/30		Count	Mean		Count	DI
MM,O.P. lines (cont.)											
Block 2 (cont.)											
US H11	L113401, 11-16-94	3.7	4.3	5.7	8.0	5.0	24	30	11.3	76.9	
R581(Sp)	RZM R481-43,-89 (C82)	3.0	4.0	4.3	6.0	4.1	22	22	9.4	85.7	
R482NB	NB R276-43,-89 (C82)	3.0	3.3	4.3	5.3	3.8	24	23	11.4	78.4	
R484	RZM R384	3.3	3.7	4.3	6.3	4.1	25	27	16.3	73.7	
R543R2	RZM R443	3.7	4.0	5.0	6.7	4.4	25	24	30.1	63.6	
R483	RZM R383(R)	3.0	3.7	4.3	6.3	4.0	24	25	14.6	77.7	
R476-43-14	RZM R376-43-14 (C76-43-14)	3.7	4.3	5.0	7.3	4.7	25	25	15.1	75.4	
R476-43-15	RZM R376-43-15 (C76-43-15)	3.0	3.7	4.0	6.7	4.2	23	21	0.8	98.3	
Block 3											
R476-89-5	RZM R376-89-5 (C76-89-5)	3.7	4.0	5.0	6.3	4.5	27	25	14.9	78.5	
R576-89-5NB	NB-ER-RZM R376-89-5	3.0	3.3	4.0	5.3	3.8	25	27	7.0	90.2	
R476-89-18	RZM R376-89-18 (C76-89-18)	3.3	3.3	4.7	6.3	4.2	23	23	11.1	81.6	
R576-89-18NB	NB-ER-RZM R376-89-18	3.0	3.3	4.3	6.0	3.9	23	22	7.8	81.9	
R576-89-18(Sp)	Inc. R476-89-18 (C76-89-18)	3.0	3.0	4.0	6.0	3.9	24	23	11.8	77.9	
R576-89-18H9	4911-4#M(C)aa x R476-89-18	3.3	3.3	5.0	6.7	4.2	24	24	8.1	79.1	
E840	Inc. E440, E640	4.0	5.0	5.7	7.3	5.3	19	23	95.1	3.7	
US H11	L113401, 11-16-94	4.0	4.7	6.3	8.0	5.3	23	28	7.9	79.2	
Y562	RZM Y462R, Y#rr(C) x R#(C)R	3.0	3.3	4.0	6.0	3.9	25	26	13.2	81.8	
Y563	RZM Y463, Y#R(C) x R#(C)R	3.0	3.3	4.3	6.3	3.9	25	26	10.8	77.6	
Y568	Y-#rr(C1) x RZM Y462,Y463,R#(C)	3.3	4.3	4.3	6.3	4.3	24	25	8.2	85.0	
Y569	Y-#rr(C2) x " "	3.0	3.3	3.7	6.3	4.0	29	28	5.9	92.7	
Y570	RZM Y462rr x " "	2.7	3.7	4.0	6.0	4.0	26	26	13.2	78.9	
U86-37	C37, 86443	4.7	4.7	6.0	8.7	5.6	26	27	16.5	75.5	
R479(Sp)	Inc. R379	3.7	4.0	5.0	7.3	4.7	26	27	4.7	91.9	
R479(Iso)	RZM R379, C79-1(Rz)	3.3	3.7	5.0	8.0	4.7	22	21	14.9	71.7	

TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew				Mean	Harvest		Stand Count	Erwinia	
		08/19	09/04	09/18	09/30		Mean	Count		DI	Rating
MMM,O.P. lines (cont.)											
Block 4											
R579	RZM R479(Iso), C79-1(Rz)	3.3	4.0	4.7	7.0	4.5	26	25	16.7	71.1	
R524	RZM R424, C79-2(WB41)	3.3	3.7	5.0	7.0	4.5	27	27	28.0	63.2	
R525	RZM R425, C79-3(WB42)	3.7	3.7	5.0	7.7	4.7	26	28	28.1	63.1	
R528	RZM R428, C79-4(PI07)	4.0	5.0	6.0	8.3	5.6	32	34	8.3	86.1	
R532	RZM R432, C79-5(R04)	4.7	4.3	5.7	7.3	5.3	30	26	35.7	59.7	
R534	RZM R434, C79-6(R05)	5.3	5.0	6.0	8.0	6.0	28	24	8.4	85.4	
R535	RZM R435, C79-7(SES)	4.0	4.7	5.0	7.3	5.1	29	27	8.8	80.3	
R536	RZM R436, C79-8(R22)	4.3	4.0	5.7	7.7	5.2	27	27	51.6	43.2	
R537	RZM R437, C79-9(WB151)	3.7	4.3	5.0	7.0	4.7	22	23	21.5	67.8	
R541	RZM R441, C79-10(WB169)	4.7	4.7	5.3	8.0	5.2	24	25	12.6	79.6	
R542	RZM R442, C79-11(WB258)	3.0	3.7	4.3	6.3	4.2	26	25	13.2	76.6	
R545	RZM 4201, (R04)	5.3	4.3	6.0	8.7	5.7	29	29	16.1	72.7	
R546	RZM 4243, (R22)	5.3	5.0	5.7	7.3	5.6	27	27	26.5	63.1	
R548	RZM 4248, (WB169)	5.0	4.7	6.0	7.7	5.5	26	27	13.9	77.0	
E840	Inc. E440, E640	5.3	4.7	5.7	7.0	5.6	21	22	96.3	3.2	
US H11	L113401, 11-16-94	4.3	4.7	6.3	8.0	5.6	25	31	10.3	75.2	
Block 5											
R549	RZM 4249, (WB258)	4.0	4.3	5.0	6.7	4.8	26	27	19.8	74.1	
R550	RZM 4247, (WB151)	4.7	4.3	5.0	7.3	5.0	28	27	16.6	73.8	
U86-37	C37, 86443	4.0	4.7	5.7	7.7	5.2	25	27	7.7	81.3	
R540-1	RZM R440-1R	4.0	4.0	5.3	6.7	4.8	28	26	6.1	89.2	
R551	U86-37 x RZM R40(C)	4.0	4.0	5.7	7.3	5.0	26	27	13.1	79.8	
R526	RZM R426R	4.7	5.0	5.0	7.7	5.4	25	25	22.2	68.3	
R540%(Iso)	RZM-%S 3201-3285	4.3	4.0	5.3	7.7	5.0	23	22	23.7	60.4	
R540(Sp)	RZM-%S 3201-3285, RZM et al.	4.0	4.7	5.3	7.7	5.1	25	26	25.4	64.2	



TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew				Harvest Count	Stand Count	Erwinia	
		08/19	09/04	09/18	09/30			Mean	DI
MM,O.P. lines (cont.)									
Block 5 (cont.)									
E840	Inc. E440, E640								
US H11	L113401, 11-16-94								
Y564(Iso)	RZM 4205,P;4206,P;...								
Y564(Sp)	" "								
Y565	RZM 4280,P;4284,P								
Y566	Y-#rr(C1) x RZM 4205,P;...								
Y567	Y-#rr(C2) x "								
R522H18	4918aa x RZM R22(C)								
Block 6									
Y522Y4	RZM-%S R322Y3,Y3%								
R522R5	RZM-%S R322R4,R4%								
R522(Sp)	RZM-%S R22(C) (C51)								
US H11	L113401, 11-16-94								
Multigerm, S', Aa Populations									
Block 6									
E840	Inc. E440, E840								
5911-4(Iso)	NB-ER-RZM 3911-4; RZM-%S 3911-4MA								
5911-4m	RZM 4911-4mmaa x A (C911-4)								
5911-4ma	RZM 4911-4mma (tagged)								
5911-4-7	T-O Sel. 4911-4-7mm								
5913-70	RZM 3913-70								
5913-71	RZM 4913-71								
4915NB	NB 2915(Sp)								
4915(Sp)	RZM 3915aa x A								
4918	RZM 3918aa x A (C918)								
5915%(Iso)	RZM-%S 3915(Sp)(A,aa)								
5915(Sp)	RZM 4911,4915,4916,4918aa x A								

TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew				Harvest		Stand		Erwinia	
		08/19	09/04	09/18	09/30	Mean	Count	Mean	Count	DI	Rating
Multigerm, S', Aa Populations (cont.)											
Block 7											
5915(C)	(C)RZM MM,Aa,Rzaa x A	3.3	4.0	4.3	6.0	4.3	25	24		7.7	82.6
5925	S <sub>1</sub> (MM,Aa,Rz)(C)aa x A	2.7	3.3	4.3	6.0	3.9	22	21		11.2	73.1
5925-15	RZM 4915-#S <sub>1</sub> (C)aa x A	2.7	3.3	4.3	6.7	3.9	23	25		9.8	81.1
5925-18	RZM 4918-#S <sub>1</sub> (C)aa x A	3.0	3.3	4.7	6.0	3.9	26	24		18.6	68.0
5924	RZM 4918aa x Y-#rrC1,C2,...	3.0	3.7	4.0	6.0	3.9	27	25		6.6	85.1
5920	RZM 4287	3.7	4.3	5.0	6.7	4.7	24	24		28.5	58.8
5921(Iso)	RZM R422R4H15,H17,...	3.7	4.7	5.0	6.3	4.6	21	23		25.7	62.9
5921(Sp)	RZM R422R4H15,H17,...	3.7	4.3	4.7	7.0	4.7	26	25		24.8	65.1
5921H18	4918 x "	2.7	3.3	4.0	7.0	4.0	25	25		13.9	79.3
5922	RZM R440H18	3.3	4.0	4.3	6.0	4.2	24	28		19.3	70.6
5923	4918aa x RZM R40(C)	3.0	4.0	5.3	7.0	4.6	24	25		15.9	70.1
R544R2	RZM R444	4.0	4.3	5.7	7.0	4.9	26	28		44.4	45.8
US H11	L113401, 11-16-94	4.7	5.0	5.7	8.0	5.4	24	29		8.1	78.2
E840	Inc. E440, E640	5.3	5.0	5.0	6.7	5.3	21	26		96.2	3.3
N523	NR-RZM N421,N422,N423,N424	3.3	4.3	5.0	7.0	4.7	20	21		11.0	83.4
N525	NR-RZM N427,N428	3.7	4.3	4.7	7.3	4.7	24	27		14.4	73.3
Block 8											
N457	NR-RZM N357 & 8-#(C)(BC <sub>3</sub> F <sub>2</sub> )(C608)	3.3	4.3	4.7	6.7	4.5	25	26		26.6	57.4
N461	NR-RZM N361 & 2-#(C)(BC <sub>3</sub> F <sub>2</sub> )(C609)	3.3	4.0	4.7	7.0	4.3	22	22		24.0	58.4
P401	PMR P201	2.3	3.0	4.0	6.3	3.8	27	28		13.6	68.5
P402NR	NR P202	3.3	3.7	5.0	7.0	4.4	29	29		10.3	79.1
P403	PMR 2211-#(C)	3.7	4.0	4.7	7.0	4.7	32	31		17.2	73.8
P404	PMR 2212-#(C)	3.0	3.7	4.7	6.3	4.1	27	25		13.1	74.4
R410	CR-RZM R210-#(C)	3.3	4.0	4.0	6.7	4.2	24	23		11.3	78.8
Z430	RZM Z330	4.0	4.3	4.3	7.0	4.7	29	28		21.0	67.1

TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	08/19	Powdery Mildew			Mean	Harvest		Stand	Erwinia	
			09/04	09/18	09/30		Count	Mean		Count	Rating
										Mean	DI

Multigerm, S', Aa Populations (cont.)

Block 8 (cont.)

4911	RZM 3911	3.0	3.3	4.0	5.7	3.8	23		23	14.0	77.1
4913-6	3913-6aa x A	3.0	4.0	4.0	7.0	4.3	20		18	15.2	66.0
4913-9	3913-9aa x A	3.0	3.7	4.0	6.7	4.0	24		22	20.5	69.9
4915-6	3915-6aa x A	2.7	3.7	5.0	6.3	4.2	28		27	10.7	77.3
4915-7	3915-7aa x A	3.0	3.3	3.7	6.0	3.8	26		28	10.8	81.9
4915-22	3915-22aa x A	2.0	3.7	4.3	6.3	3.9	22		23	17.9	70.6
4915-34	3915-34aa x A	3.0	3.3	4.7	6.7	4.1	23		23	4.5	89.2
4916	RZM 3916	3.3	3.7	5.3	7.3	4.7	26		26	10.5	83.5

Block 9

4917	RZM 3917	2.3	3.7	4.0	6.0	3.8	25		28	6.8	89.7
US H11	L113401, 11-16-94	4.0	4.7	5.7	8.7	5.3	23		28	9.6	77.0
E840	Inc. E440, E840	4.7	4.7	5.0	6.7	4.9	22		26	96.6	3.2
U86-37	C37, 86443	3.3	4.3	6.3	8.0	5.1	26		26	10.0	80.4

Mono germ, S', Aa Populations

Block 9

0790	8790-S <sub>1</sub> (C)aa x A (C790)	3.3	3.3	5.0	6.7	4.3	28		29	17.3	66.9
4890m	RZM 3890mmaa x A (C890)	4.0	4.3	5.0	7.0	4.8	28		28	20.5	58.6
5890	3890-S <sub>1</sub> (C)mmaa x A (C890-1)	4.3	4.0	5.0	7.0	4.7	26		26	16.5	65.8
5890HO	4890HO x " (C890-1HO)	4.0	4.0	5.0	7.0	4.6	29		27	22.4	58.0
5890A	Inc. 3890-S <sub>1</sub> (C)mmaa (C890-1)	4.0	3.7	4.7	7.3	4.7	23		25	18.5	64.9
5810	0790mmaa x 4265-4279(C) (C890-#s)	3.7	4.7	4.7	7.0	4.8	27		29	17.2	70.3
5811	4890mmaa x 4265-4279(C)	4.0	4.3	5.0	7.0	4.9	28		28	17.2	72.4
5812	RZM 4275 (WB41, WB42) (C890-2/3)	4.0	4.7	6.0	7.7	5.3	30		31	11.9	75.8

TEST 1396. ERWINIA/POWDERY MILDEW EVALUATION OF LINES, SALINAS, CA., 1996

(cont.)

Variety	Description	08/19	Powdery Mildew			Mean	Harvest		Stand Count	Erwinia	
			09/04	09/18	09/30		Count	Mean		Rating	%R
Monogerm, S'Aa Populations (cont.)											
Block 9 (cont.)											
5814	RZM 4267 (PI07) (C890-4)	3.7	4.0	5.0	7.0	4.5	31	31	15.8	77.4	
5815	RZM 4265 (R04) (C890-5)	4.0	4.3	4.3	7.0	4.7	27	28	24.9	65.7	
5817	RZM 4268, 7, P (SES, R05) (C890-6/7)	5.0	5.0	5.7	7.7	5.4	26	25	16.5	65.9	
5818	RZM 4270, 2 (R22) (C890-8)	3.7	4.3	5.0	7.0	4.7	30	30	18.8	70.4	
Block 10											
5819	RZM 4273 (WB151) (C890-9)	3.0	3.7	5.0	6.7	4.3	22	25	42.7	39.6	
5820	RZM 4278, 9, P (WB169, WB258) (C890-10/11)	3.7	4.0	4.7	6.7	4.6	25	26	28.5	52.1	
5822m	4265-4279mmaa x A (C890-#s)	3.7	4.3	4.3	6.0	4.4	27	28	27.9	55.3	
5869	3867-#(C)mmaa x 3890-#(C)	3.3	3.3	4.7	6.3	4.1	30	28	34.4	57.8	
4831	3911-4m, mmaa x mm, O-T(C)	4.0	4.0	5.0	6.7	4.7	27	28	11.9	84.2	
4833	RZM 3867m(Sp)aa x mm, O-T(C)	4.3	4.3	5.3	7.3	4.9	23	21	30.0	59.4	
4834	RZM 3894m, aa x mm, O-T(C)	4.0	4.3	5.0	7.0	4.8	24	22	37.8	49.0	
5834	RZM 4834	4.0	4.0	5.7	7.3	4.8	27	26	27.7	56.3	
4859m	RZM 3859, ...mmaa x A, (C859)	3.0	4.3	5.0	7.7	4.8	17	18	46.4	30.1	
5859%	RZM-# 3859m(Sp) (C859)	3.7	4.0	4.7	8.0	4.8	22	24	54.6	31.1	
4865m	RZM 3865, ...mmaa x A	4.0	4.3	5.3	8.0	5.1	21	20	34.0	50.1	
5893	RZM 4893(A, aa)	4.0	4.7	5.3	7.7	5.1	27	26	65.8	22.1	
4894	RZM 3894m	4.3	4.7	5.3	7.0	4.9	24	25	43.4	43.3	
5895	RZM 4895, 4833	4.0	4.3	5.0	7.7	5.0	26	26	34.4	56.0	
5867(T-O)	T-O Sel. 4867-#'s	3.3	4.0	4.7	7.3	4.6	24	21	45.6	42.6	
5867NB	Inc. 3867-3, 4, 5, 7, 8	3.7	4.3	5.3	7.7	4.8	25	24	39.6	44.1	
Mean		3.5	4.0	4.8	6.8	4.5	24.9	25.5	22.1	68.0	
LSD (.05)		1.0	1.0	0.9	1.0	0.6	5.3	5.0	11.0	15.6	
C.V. (%)		18.1	15.3	11.6	9.0	8.1	13.3	12.2	31.0	14.3	
F value		3.7**	2.3**	4.4**	4.6**	7.0**	1.9**	2.1**	27.5**	13.1**	

NOTES: See footnotes for test 1296.

TEST 1296. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS, SALINAS, CA., 1996

80 entries x 3 replications  
1-row plots, 18 ft. long

Planted: April 12, 1996  
Scored: October 11, 1996  
Inoc. Ecb: July 11, 1996

Variety	Description	Powdery Mildew					Harvest		Stand		Erwinia		
		08/19	09/04	09/18	09/30	Mean	Count	Mean	Count	Mean	DI	Rating %R	
Block 1													
US H11	L113401, 11-16-94	3.7	4.3	5.3	8.0	4.9	29	30	6.4	87.8			
E840	Inc. E440, E640	4.7	5.0	5.7	7.7	5.5	23	24	97.1	0.0			
E840H72	U83-718HO x E440, E640	4.7	4.7	5.7	7.7	5.3	27	28	79.1	10.6			
E840H8	F82-546H3 x E440,E640	4.0	4.0	5.7	8.0	4.8	30	28	41.8	41.6			
SS-NB7	L950840, 11-13-95	4.0	4.0	5.0	7.3	4.7	21	21	26.0	65.6			
Rival	HH103, L1031203, 8-29-95	4.0	4.7	4.7	7.0	4.8	27	28	10.4	85.0			
4006R	Betaseed, 2-8-96	3.7	4.3	5.0	7.0	4.6	21	21	47.6	37.4			
WS-PM9	HM-WS-PM9, 4-18-95	3.3	4.0	4.3	6.0	4.1	25	25	18.4	69.7			
Block 2													
Rizor	F291, 2-13-96	4.7	5.0	5.3	7.7	5.4	24	25	3.5	91.3			
SS-781R	941000, 8-21-95	3.0	4.0	5.0	7.3	4.3	22	22	16.1	74.4			
SS-694R	Spreckels, 11-13-95	3.3	4.0	5.3	7.7	4.6	25	25	11.3	82.7			
R578H8	F82-546H3 x RZM R478NB	4.0	4.3	4.7	7.3	4.7	26	26	11.4	82.8			
R578H20	U87-309H3 x RZM R478NB	3.7	3.7	4.7	8.0	4.6	22	23	14.6	78.7			
R578H37	4807HO (C306CMS) x RZM R478NB	3.3	4.0	4.7	7.0	4.4	24	22	22.2	66.1			
R578H39	91-762-17CMS x RZM R478NB	3.0	3.7	4.0	7.0	4.1	23	23	26.6	56.4			
R578H51	F92-790-15H26 x RZM R478NB	3.3	4.0	4.3	7.0	4.3	28	25	27.9	58.4			
Block 3													
R578H50	F92-790-15CMS x RZM R478NB	3.0	3.7	4.7	6.7	4.1	26	27	22.9	66.7			
R78H50-#	4790-15-#(C)CMS x RZM R478NB	3.0	3.7	4.0	6.3	3.9	24	26	29.1	58.3			
R578H50-21	4790-15-21CMS x RZM R478NB	3.0	3.7	4.7	6.7	4.1	25	26	22.0	63.3			
R578H50-23	4790-15-23CMS x RZM R478NB	3.0	4.0	4.3	7.0	4.2	26	23	20.4	69.2			
R578H52	F92-790-15H39 x RZM R478NB	3.0	3.7	4.3	6.7	4.1	24	24	25.3	58.4			
R578H12	4911-4H50 x RZM R478NB	3.0	3.7	4.7	7.0	4.2	26	26	13.0	82.3			
US H11	L113401, 11-16-94	4.7	5.0	6.0	8.0	5.5	25	28	11.6	77.5			
E840	Inc. E440, E640	5.0	5.0	5.3	7.7	5.4	29	27	93.7	4.9			

TEST 1296. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew					Harvest		Stand Count	Erwinia	
		08/19	09/04	09/18	09/30	Mean	Count	Mean		DI	Rating
Block 4											
R581H50	F92-790-15CMS x RZM R481-43,-89	3.0	3.3	4.0	6.7	3.9	26	27	19.4	66.3	
R581H51	F92-790-15H26 x RZM R481-43,-89	3.3	4.0	5.0	7.0	4.5	25	26	10.2	79.9	
R581H12	4911-4H50 x RZM R481-43,-89	3.3	3.7	4.3	6.7	4.2	25	25	6.7	87.2	
R581H11	4911-4m,aa x RZM R481-43,-89	2.3	4.0	4.0	6.3	3.8	24	24	6.1	91.5	
R581H87	RZM 4890m,aa x RZM R481-43,-89	3.0	3.7	4.3	7.0	4.2	26	25	11.8	76.7	
R576-89-18H50	F92-790-15CMS x R476-89-18	3.0	3.7	4.0	6.7	4.0	26	25	24.7	60.2	
R576-89-18H9	4911-4#M(C)aa x R476-89-18	3.3	3.7	4.7	7.0	4.4	26	25	6.7	85.1	
R576-89-18H87	4890m,aa x R476-89-18	3.3	4.0	5.0	7.0	4.4	24	25	23.7	63.2	
Block 5											
5911-4H50(Sp)	F92-790-15CMS x RZM 4911-4m	3.3	4.0	4.0	6.7	4.1	28	27	19.4	75.0	
4911-4H50(Iso)	F92-790-15CMS x NB-ER-RZM 3911-4	3.0	3.7	4.0	6.7	3.9	24	23	16.9	75.2	
5913-70H50	F92-790-15CMS x RZM 3913-70	3.0	4.0	4.3	7.3	4.2	23	23	10.9	75.6	
5913-71H50	F92-790-15CMS x RZM 4913-71	3.7	4.0	4.7	7.0	4.4	24	24	60.5	23.6	
R576-43-14H50	F92-790-15CMS x RZM R476-43-14	3.3	4.0	4.7	7.0	4.3	26	26	12.9	79.1	
R576-43-15H50	F92-790-15CMS x RZM R476-43-15	3.0	3.3	3.7	6.0	3.7	24	24	13.2	73.8	
R576-89-5H50	F92-790-15CMS x RZM R476-89-5	3.3	3.3	4.7	6.7	4.2	26	26	7.3	88.2	
R576-89-18H50	F92-790-15CMS x RZM R476-89-18	3.3	3.7	5.0	6.3	4.2	25	25	16.7	63.8	
Block 6											
5921H50	F92-790-15CMS x RZM R21(C)	3.3	4.0	4.0	7.3	4.2	24	26	14.6	73.5	
R540H50	F92-790-15CMS x RZM R40(C)	2.7	4.0	4.0	7.0	4.1	29	28	30.0	57.8	
US H11	L113401, 11-16-94	4.3	4.7	6.0	7.7	5.4	29	31	3.6	92.4	
E840	Inc. E440, E640	5.7	4.7	5.0	7.0	5.4	25	25	96.5	1.3	
R522H50	F92-790-15CMS x RZM R22(C)	3.7	4.0	4.3	7.0	4.4	28	28	53.9	34.9	
R479H50(Sp)	F92-790-15CMS x R379	3.3	3.3	3.7	7.3	4.2	28	29	9.9	84.6	
R579H50	F92-790-15CMS x RZM R479(Iso)	3.3	3.7	4.3	6.7	4.2	28	27	22.5	56.3	
R543R2H50	F92-790-15CMS x RZM R443	3.3	4.0	5.0	7.0	4.4	26	25	45.3	44.5	

TEST 1296. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew				Mean	Harvest		Stand Count	Erwinia	
		08/19	09/04	09/18	09/30		Count	Mean		DI	Rating %R
Block 7											
RR544R2H50	F92-790-15CMS x R2M R444	3.3	4.0	4.3	7.0	4.2	27	26	41.1	47.5	
RR422R4H50	F92-790-15CMS x R2M R322R4,...	3.0	3.7	4.7	7.0	4.2	28	26	60.7	26.6	
RR422Y3H50	F92-790-15CMS x R322Y3,%	3.0	4.0	4.3	7.0	4.2	23	26	45.4	42.6	
RR480-45H8	F82-546H3 x R280-45	3.7	3.7	5.0	7.7	4.5	26	27	22.3	64.3	
RR480-45H50	F92-790-15CMS x R280-45	2.7	4.0	4.0	6.7	4.1	23	24	11.3	83.4	
4918H50	F92-790-15CMS x R2M 3918	2.7	3.7	4.0	6.0	3.8	24	25	26.5	58.0	
4918H8	F82-546H3 x R2M 3918	3.3	3.7	5.0	7.3	4.5	24	25	14.0	76.0	
RR578H3	F82-562H0 x R2M R478NB	3.7	4.3	5.3	8.0	4.9	25	26	25.4	60.9	
Block 8											
RR578H19	4918-#(C)aa x R2M R478NB	2.7	3.0	3.3	6.0	3.6	24	26	11.3	82.2	
RR578H59	4859m,aa x R2M R478NB	2.7	4.3	4.3	7.0	4.2	24	24	28.6	58.5	
RR578H65	4865m,aa x R2M R478NB	4.0	4.3	4.7	7.0	4.6	23	25	21.4	72.7	
RR578H87	4890m,aa x R2M R478NB	3.0	4.0	4.7	6.7	4.2	26	26	24.2	60.8	
RR578H93	4893aa x R2M R478NB	3.3	3.7	4.3	7.3	4.2	26	26	19.5	69.3	
RR578H94	4894aa x R2M R478NB	3.7	4.0	5.3	7.3	4.7	23	24	26.8	60.8	
RR578H74	4859-2H50 x R2M R478NB	3.3	4.0	4.7	7.0	4.3	26	27	30.0	54.1	
RR578H75	4865-4H50 x R2M R478NB	2.7	4.3	5.3	7.7	4.6	24	23	24.6	60.8	
Block 9											
RR578H76	4867-1H50 x R2M R478NB	3.7	4.0	4.7	7.0	4.5	21	23	40.9	47.5	
RR578H77	4891-4H50 x R2M R478NB	2.7	3.3	3.7	6.7	3.7	27	25	21.7	65.6	
RR578H78	4864-8H50 x R2M R478NB	3.7	3.7	4.3	6.7	4.2	27	27	24.8	63.6	
RR578H79	4864-14H50 x R2M R478NB	3.3	3.7	4.3	7.0	4.3	28	28	12.7	79.8	
RR578H80	4864-34H50 x R2M R478NB	3.3	3.7	4.0	6.7	4.1	27	28	27.0	62.4	
RR578H50	F92-790-15CMS x R2M R478NB	3.0	4.0	4.3	6.7	4.2	25	26	23.5	66.7	
US H11	L113401, 11-16-94	5.0	4.3	5.7	8.0	5.4	25	28	5.4	87.7	
E840	Inc. E440, E640	5.3	5.0	5.3	7.0	5.3	26	26	96.0	1.1	

TEST 1296. ERWINIA/POWDERY MILDEW EVALUATION OF HYBRIDS, SALINAS, CA., 1996

(cont.)

Variety	Description	Powdery Mildew				Harvest		Stand		Erwinia	
		08/19	09/04	09/18	09/30	Mean	Count	Count	Mean	DI	%R
Block 10											
R581H65	RZM 4865m,aa x RZM R481-43,-89	3.3	3.7	4.3	7.0	4.2	24	24	24	15.8	76.3
R581H65NB	RZM 4865NBaa x RZM R481-43,-89	3.0	4.3	4.7	7.3	4.6	25	25	25	14.9	77.3
R576-89-18H19	4918-#(C)aa x R476-89-18	3.0	3.7	4.0	6.7	3.9	23	23	24	3.0	90.3
5911-4H87	4890m,aa x RZM 4911-4m	3.7	4.3	5.0	7.0	4.6	25	25	26	11.0	83.1
5921H18	4918aa x RZM R21(C)	3.3	3.0	4.3	6.7	3.9	23	23	24	19.0	65.1
R522H18	4918aa x RZM R22(C)	3.0	3.7	4.3	7.0	4.1	23	23	23	18.8	72.8
5924	RZM 4918aa x Y-#rr(C1),...	3.3	3.7	3.7	6.3	3.8	28	27	27	9.2	81.4
5923	4918aa x R40(C)	3.7	3.7	4.7	7.0	4.3	26	25	25	14.3	71.7
Mean		3.4	4.0	4.6	7.0	4.4	25.3	25.5	25.5	25.4	64.4
LSD (.05)		1.0	0.8	1.0	0.8	0.6	4.9	4.0	4.0	15.7	21.5
C.V. (%)		17.8	12.6	14.1	7.0	7.9	12.1	9.6	9.6	38.3	20.7
F value		3.3**	2.3**	2.3**	2.9**	5.3**	1.3NS	1.8**	1.8**	14.5**	7.9NS

**NOTES:** Powdery mildew scored on a scale of 0 to 9 where 9 = highly susceptible.

For Erwinia ratings, individual plants within a plot were scored based upon approximate % rot (0,1,7,25,50,75,93,100% rot). DI (diseased index) = the average rot per beet. %R (% resistant) = the percentage of plants rated 0 - 7% rot. Following inoculation, Erwinia developed well. This was a moderately severe test. There did not appear to be other confounding root rots or diseases.

See test 296 for more complete hybrid descriptions.



TEST 5296. PLANT INTRODUCTION (PI) EVALUATION FOR RESISTANCE TO  
BWV (VIRUS YELLOWS) AND RHIZOMANIA, SALINAS, CA., 1996

32 entries x 3 replications  
1-row plots, 12 ft. long

Planted: June 3, 1996  
Harvested: January 7, 1997  
Natural infection to BWV

P.I. # Variety	Harvest Count	End Use <sup>1</sup>	Population Uniformity <sup>2</sup>	Leaf Blade Pigment <sup>3</sup>	Petiole Color <sup>4</sup>	Bolting Tendency <sup>5</sup>	BWV <sup>6</sup>	RZM Score <sup>7</sup>
PI 518426	39	6	2	2	6	2	3	8
PI 518435	42	5	1	2	4	2	3	8
PI 518440	44	6	1	2	6	2	3	5
PI 531260	64	2	1	3	3	2	3	4
PI 535826	50	7	1	1	4	2	3	7
PI 535833	50	6	2	2	6	2	4	4
PI 535834	52	5	1	1	1	2	5	7
PI 535835	53	5	1	2	1	2	4	5
PI 535838	37	5	1	1	1	2	6	8
PI 535840	62	5	1	1	1	2	5	9
PI 535841	44	5	1	1	1	2	4	9
PI 535843	52	6	2	2	6	3	4	4
PI 535845	47	5	1	1	1	2	5	8
PI 535846	65	2	2	3	3	2	3	7
PI 540561	50	7	2	2	6	1	4	8
PI 540562	44	6	1	2	6	1	5	7
PI 540564	46	7	1	2	6	1	4	7
PI 540568	44	6	2	2	6	3	4	8
PI 540575	47	6	1	2	6	2	4	5
PI 540588	51	7	2	2	6	3	3	3
PI 540593	39	6	2	2	1	2	4	7
PI 540596	37	6	2	2	6	2	3	6
PI 540598	43	7	2	2	6	3	3	6
PI 540599	42	7	2	2	1	2	4	7
PI 540600	35	6	2	2	6	3	4	4
PI 540601	51	6	1	2	6	2	4	1
PI 540602	41	6	1	2	6	3	4	5
PI 540603	52	5	1	2	6	2	3	3
PI 540604	38	7	2	2	6	3	3	0
PI 540605	55	7	1	2	6	3	4	5
Checks								
R539	51	5	1	1	1	2	4	0
R22 (Sp)	56	5	1	2	1	2	4	0

TEST 5296. PLANT INTRODUCTION (PI) EVALUATION FOR RESISTANCE TO  
BWYV (VIRUS YELLOWS) AND RHIZOMANIA, SALINAS, CA., 1996

(cont.)

P.I. # Variety	Harvest Count	End Use <sup>1</sup>	Population Uniformity <sup>2</sup>	Leaf Blade Pigment <sup>3</sup>	Petiole Color <sup>4</sup>	Bolting Tendency <sup>5</sup>	BWYV <sup>6</sup>	RZM Score <sup>7</sup>
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<sup>1</sup> End Use based upon field appearance where: 1 = chard; 2 = DDR-like; 3 = DDR, chard, spinach;  
4 = fodder; 5 = sugar; 6 = wild beet type; 7 = mixed.

<sup>2</sup> Population Uniformity: 1 = all plants alike; 2 = uneven different types; 3 = mixed: green,  
red, yellow, high, low, large leaves, small leaves, etc.

<sup>3</sup> Mature Leaf Blade Pigmentation: 1 = light green (chard); 2 = green; 3 = red & green;  
4 = red; 5 = mutant.

<sup>4</sup> Petiole Color: 1 = green; 2 = pink; 3 = red; 4 = candy stripe; 5 = yellow; 6 = mixed.

<sup>5</sup> Bolting Tendency without cold induction: 1 = B\_ (annual) 100%; 2 = bb (biennial) 0%;  
3 = B:bb (mixed) 1-99%.

<sup>6</sup> Beet Western Yellows (BWYV) based upon yellowing of leaves: 0 = immune; 1 = very resistant;  
3 = resistant; 5 = intermediate; 7 = susceptible; 9 = highly susceptible.

<sup>7</sup> Rhizomania: DI (disease index) based upon: 0 = no visual symptoms; 1 = very minor root  
symptoms; 3 = normal tap root, slight bearding; 5 = wine-glass shaped, bearded, moderate damage;  
7 = severely damaged, loss of tap root; 9 = dead due to rhizomania. % Healthy = classes  
(0+1+2+3)/total. Classified at time of harvest, January 7, 1997.

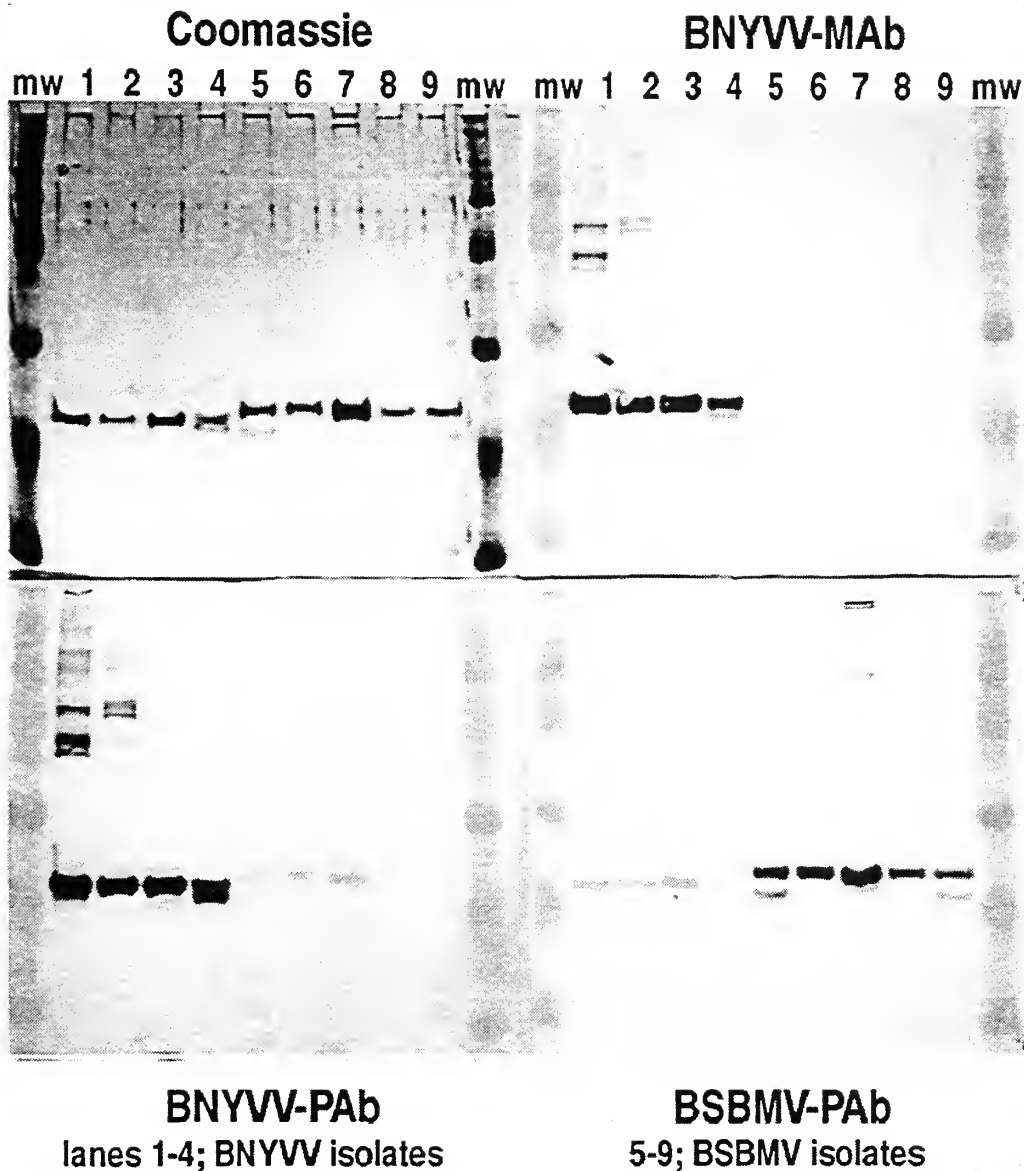
**NOTES:** The 30 PI accessions were planted June 3, 1996 at the Agricultural Research Station in  
Salinas, CA. Two USDA checks were planted: R539 (C39R) = resistant to rhizomania and  
tolerant to virus yellows, and R522(Sp) (C51) = resistant to rhizomania and susceptible  
to virus yellows. Yellowing symptoms were scored on a plot basis (11/25/96) following  
natural infection. At the end of the season the plants were lifted and evaluated for  
visual feeder root symptoms. Rhizomania symptoms were moderately severe. Harvest (1/7/97)  
was done under unfavorable wet conditions due to rainfall and scoring plots was adversely  
affected.

Characterization of Furoviruses Infecting Sugar Beets and Improvements in  
Soil Tests for Rhizomania Using Molecular and Immunological Probes  
G. C. Wisler, J. E. Duffus, and H.-Y. Liu  
Projects 203, 280

These two projects which have been reported separately in the past, will be reported together due to the overlap in research emphasis. Results derived from the overall characterization of sugar beet furoviruses are applied towards our understanding of relationships among these viruses and an improved ability to correctly diagnose beet necrotic yellow vein virus (BNYVV), the cause of rhizomania. In addition, an important aspect of this research is to distinguish BNYVV from other, related furoviruses infecting sugar beet.

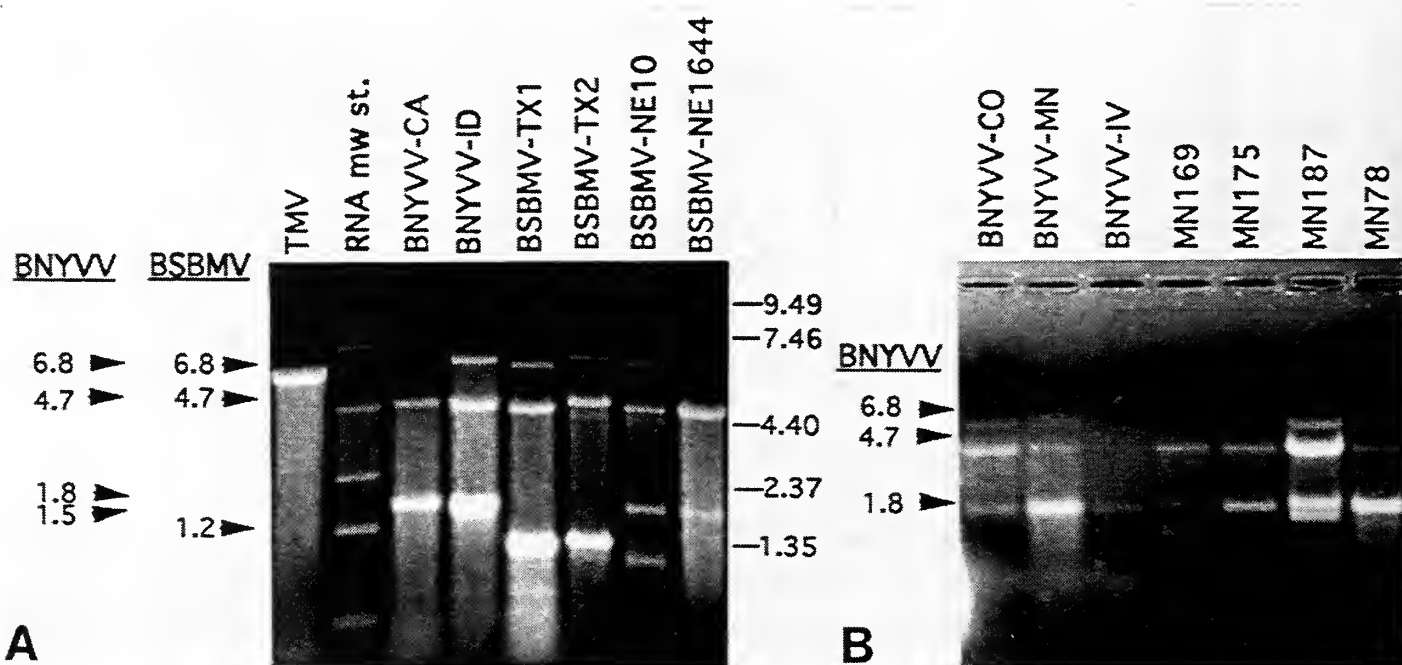
Previous research has shown that all isolates of BNYVV collected and isolated in pure culture from California, Nebraska, Idaho, Colorado, and Minnesota are identical to one another based on (1) serological identity of the coat protein and of the 14, 25, 42, and 75 kilodalton (kDa) nonstructural proteins, (2) homology in Northern and dot blot analyses of viral RNAs 1, 2, 3, and 4, (3) typical reactions of BNYVV on all indicator plants, (4) RT-PCR analyses of several regions of the BNYVV genome, and (5) size and number of RNAs.

Another group of furoviruses infecting sugar beet in the United States called beet soil borne mosaic virus (BSBMV) have been isolated from all the states listed above except California. They have the rigid, rod-shaped morphology of the furovirus group, and two isolates have been shown in our greenhouse studies to be transmitted by *Polymyxa betae*. These isolates are identical to one another based only on the serology of the capsid protein (CP), thus will be referred to as a "serogroup". Whereas BNYVV has a CP molecular mass of ca. 22 kDa, the BSBMV isolates all have a molecular mass of ca. 24 kDa. A low level of reciprocal cross-reactivity exists between the antisera to the CP of BNYVV and BSBMV and these have been observed in every western blot tested whether the antisera is made to the purified BNYVV virions or to the BNYVV CP which was cloned and expressed in *E. coli* (Fig. 1). This indicates a true serological relationship rather than contamination of the purified virus preparation used for antiserum production. Cross-reactivity can be eliminated by the use of monoclonal antibodies to BNYVV which have been kindly provided by L. Torrance and G. Grassi. Low levels of cross-reactivity can also be observed in ELISA tests, depending on the dilution of polyclonal antisera used. No cross-reactivity has been observed between these two viruses in immunodiffusion tests as this technique is less sensitive than ELISA or Western blots, and thus less likely to show low levels of relatedness.



**Fig. 1.** Polyacrylamide gel electrophoretic gel presented as: top left; a Coomassie stained gel, top right; a Western blot using a monoclonal antibody (MAb) to BNYVV (courtesy of G. Grassi), bottom left; Western blot using polyclonal (PAb) BNYVV antiserum, and bottom right; polyclonal antisera to BSBMV. Samples are purified preparations of each virus. From left to right: lanes 1-4 are BNYVV isolates, lanes 5-9 are BSBMV isolates. Lane 1; BNYVV-California, lane 2; BNYVV-Nebraska, lane 3; BNYVV-Colorado, lane 4; BNYVV-Minnesota. Lanes 5 and 6; two BSBMV isolates from Texas, lane 7; BSBMV-Nebraska, lane 8; BSBMV-Colorado, lane 9; BSBMV-Minnesota. The Coomassie gel shows the molecular mass of the BNYVV isolates at ca. 22 kDa and the BSBMV isolates at ca. 24 kDa. The western blots show specificity for BNYVV using BNYVV a monoclonal antibody, and reciprocal cross-reactivity between BNYVV and BSBMV using respective polyclonal antisera.

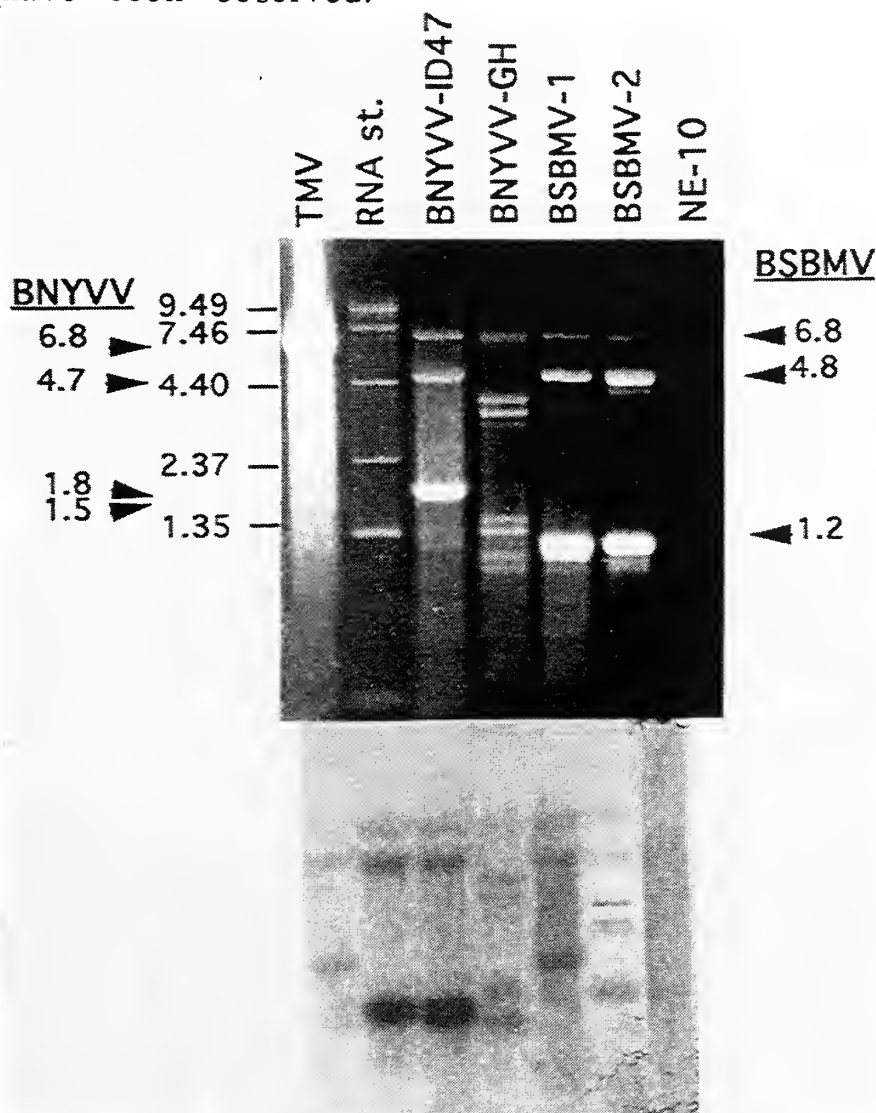
BSBMV isolates can be distinguished from one another based on their reactions on host indicator plants, and the size and number of their RNAs. Each isolate is somewhat distinctive in their reaction on indicator plants and these are stable characteristics for identification. The pattern of viral RNAs are different from one another, based on the isolate, and these are also stable characteristics for each isolate tested (Fig. 2A and 2B). Two original isolates of BSBMV from Texas show the same RNA pattern as preparations in 1996 as was seen when the virus was first isolated in 1985. BSBMV isolates which have been collected from other areas in the United States show different RNA patterns, some of which are apparently identical to BNYVV.



**Fig. 2A & B.** Ethidium bromide stained 1.0% agarose gels run under denaturing conditions showing the RNAs of several BNYVV and BSBMV isolates. The sizes of the BNYVV RNAs and the original BSBMV isolates from Texas in kilobase pairs (kbp) are shown on the left of the gels. The isolates indicated as MN are recent BSBMV serotype isolates obtained from Minnesota. A variety of BSBMV RNA sizes are seen which are distinct from the original BSBMV isolates from Texas.

In the fall of 1996 rhizomania was positively identified in Minnesota for the first time and several isolates of BNYVV and BSBMV were collected from the area. Again BNYVV was identical to previous isolates studied in the United States, and a variety of BSBMV isolates were also identified. Although serologically identical, the RNA pattern of the BSBMV isolates were different but stable, and reactions on indicators differed as well. A few samples which were borderline or negative in ELISA were positive in

Western blots, showing the increased sensitivity of Western blot analyses. In greenhouse studies using a new isolate of BSBMV from Minnesota, severe symptoms of mosaic and reduction of growth are seen in approximately 40% of the plants inoculated, but no evidence of rhizomania symptoms have been observed.



**Fig. 3.** An ethidium bromide stained 1.0% agarose gel (top) and the corresponding Northern blot (bottom) probed with a biotinylated oligo-dT probe indicating polyadenylation of the BNYVV and BSBMV RNAs. The lanes shown in the agarose gel from left to right, are shown as a mirror image below from right to left. TMV is not polyadenylated. However, the RNAs seen in the ethidium stained gel of BNYVV and BSBMV, as well as the RNA standards are polyadenylated, seen by the corresponding RNAs below. The NE-10 is an isolate which is serologically identical to BSBMV. The BNYVV-GH isolate is an original BNYVV isolate which has been maintained by mechanical inoculation in the greenhouse for over 10 years. Although it still reacts with BNYVV antisera, the RNA pattern has changed

significantly. The sizes of the BNYVV RNAs are indicated on the left, and those of BSBMV-Texas are indicated on the right.

Using BNYVV as a positive control for polyadenylation and tobacco mosaic virus (TMV) as a negative control, BSBMV isolates were tested for polyadenylation of their RNAs, an important characteristic for classification and identification of viruses. The RNAs which are visible in the ethidium bromide-stained agarose gel also reacted with a biotinylated oligo-dT probe, indicating that the viral RNAs of all isolates tested (except TMV) and the RNA standards were also polyadenylated (Fig. 3). This was accomplished by running a denaturing gel of viral RNA extracted from purified preparations of BNYVV and BSBMV isolates. The gel was transferred to a nylon membrane, and hybridized overnight with a biotinylated oligo-dT probe. The membrane was then reacted with a streptavidin-alkaline phosphatase conjugate and the final reaction with a colorimetric substrate.

Several antisera to BNYVV and BSBMV structural (CP) and nonstructural proteins have been evaluated in ELISA and Western blot assays. Because of its ability to distinguish differences in molecular mass and the range of specificities seen between polyclonal and monoclonal antibodies, the Western blot is the best technique evaluated with a sensitivity of 78 picograms of virus detected. Complimentary DNA (cDNA) clones to BNYVV (obtained from the ATCC) and to BSBMV (made in Salinas) RNAs have been evaluated for their ability to distinguish between the two viruses in dot blot and Northern blot analyses. Using these techniques there is enough cross-reactivity observed as to confuse diagnosis. This indicates a relationship between these two viruses as has been suggested by other assays. Additional tests will be evaluated for their sensitivity and specificity including immunocapture-PCR. Using monoclonal antisera to BNYVV and primers that are known to only amplify BNYVV this may prove to be a better routine test for rhizomania.

As BNYVV and BSBMV isolates are added to our collection, it appears that the BNYVV isolates are identical which suggests a single introduction into the United States based on the epidemiology of this virus. In contrast, the BSBMV isolates collected from this country are diverse genetically and biologically, although they are serologically identical. This would indicate that a serogroup has developed in the United States, and suggests that this virus may be endemic to this country. Other reports (Rush, personal communication) indicate that BSBMV has not been found in Europe or the United Kingdom. BNYVV and BSBMV are more alike in terms of their genome organization and polyadenylation than they are to the type member of the furovirus group, soil-borne wheat mosaic virus (SBWMV) and another furovirus, beet soil borne virus (BSBV). Our work is in

agreement with the suggestion by Dolja et al (1994) that BNYVV and BSBMV belong to a new subgroup of fungus-transmitted, rod-shaped viruses.

Acknowledgements: We would like to thank our BSDF and USDA employees Jeff Wasson, Samuel Rangel, Art Cortez, and John Sears. for their excellent technical assistance in all aspects of this research.



# **Evaluation of Photosynthetic Parameters in the Selection of Varieties with Improved Rates of Sugar Production**

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94720

## **Introduction:**

The goal of this research is to identify physiological parameters in young plants which can serve as markers to facilitate the selection of superior-yielding sugar beet genotypes. One such physiological parameter is chlorophyll fluorescence. Chlorophyll fluorescence is the portions of the absorbed light that are always re-emitted by plant leaves when light is absorbed by chlorophyll molecules for photosynthesis. Other portions of the absorbed light may be lost as heat. Since these decay processes of excited chlorophyll are competitive, the intensity of the emitted fluorescence is considered to be a sensitive indicator of the leaf's photosynthetic activity. Chlorophyll fluorescence originates mainly from chlorophyll molecules associated with Photosystem II (PSII). Hence, fluorescence yield reflects the properties of excitation and energy conversion as PSII. The function of PSII is known to be affected by various environmental stresses and very good correlations have been found between leaf fluorescence characteristics and several stresses, e.g., photoinhibition of photosynthesis, frost-killing temperature, high temperature, and drought. Recent studies have proven that chlorophyll fluorescence provides a rapid non-destructive method for studying heat and drought stress tolerance in plants (Ogren, 1990; Prange et al., 1990; Jefferies, 1992; Smillie, 1992). However, due to the functional connection of PSII to the other components of the photosynthetic apparatus, fluorescence yield is considered to be a sensitive indicator not only of

environmental stress but also of the state of activity of the entire photosynthetic process (Schreiber and Bilger, 1987). Recent improvements in fluorescence techniques, particularly the development of the pulse modulation chlorophyll fluorometer, have served to increase the value of fluorescence as a nonintrusive method of monitoring photosynthetic events and judging the physiological state of the plant (Krause and Weis, 1991).

There is evidence that sucrose storage and partitioning is physiologically linked to photosynthetic rate (Wardlaw, 1990) and that changes in the latter are reflected by changes in fluorescence (see also Krause and Weis, 1991). Krause and Weis (1991) have shown that  $F_v/F_m$  ratio (the ratio between variable fluorescence and maximum fluorescence) is an important and easily measurable parameter of the physiological state of the photosynthetic apparatus in intact plant leaves. Furthermore, Bolhàr-Nordenkamp and Öquist (1993) have shown (by calculations of rate constants for competing decay reactions at  $F_0$  and  $F_m$ ) that this ratio is proportional to the quantum yield of overall photosynthesis. They also indicated that the correlation between  $F_v/F_m$  and photosynthetic rate is highly reproducible at least in the case of photoinhibition. In our research we have shown that  $F_v/F_m$  is also strongly correlated with storage root sucrose concentration and content, i.e., that chlorophyll fluorescence is linked to the storage of sucrose as well as to its production. Thus, it appears that sucrose concentration and sugar yield of storage roots are linked physiologically to chlorophyll fluorescence.

The use of chlorophyll fluorescence as an innovative screening method for the rapid identification of plants with superior yield potentials has distinct advantages since large numbers of very young plants can be screened very quickly using a portable pulse modulated PAM fluorometer. In previous years, we found two fluorescence parameters,  $(F_v)_s$  and  $F_v/F_m$ , which were highly promising as yield predictors, i.e., selection for these parameters in a population of young plants was successful in predicting which plants

would later have high sucrose yields or percent sucrose. The long-term goals of our research are 1) to develop the fluorescence approach into a simple and easily-workable technique for the rapid selection of high yielding genotypes, and, 2) to apply the technique for the actual development of new better-yielding varieties.

The data we have obtained to date prove that fluorescence technique can be used for the rapid selection of superior-yielding individual plants. Thus, we have fulfilled our first long-term goal. During 1995, we used the fluorescence prescreening technique to identify superior-yielding individuals from populations of five sugar beet genotypes that had already been selected (by Van der Have) for large storage root volume. The results of that study showed that when fluorescence prescreening is used for sugar beet plants with large roots, genotypes can be obtained which have superior yields both in terms of total root sugar and sugar percentage. However, results obtained in 1995 differed from our earlier results obtained in 1994 in that increases in  $(F_v)_s$  and  $F_v/F_m$  were correlated positively with increases in storage root sugar yield and percent; in 1994, the correlations were negative. We hypothesized that large rooted plants have sinks for photosynthate (sugar) which are sufficient to accommodate increases in sugar production resulting from increased photosynthetic rate associated with plants selected for high  $(F_v)_s$  and  $F_v/F_m$  values. These large-rooted genotypes tend to have low sugar concentrations which may be substantially increased, thereby allowing large increases in total sugar yield. Plants with small storage roots by comparison, may have insufficient root volumes to accommodate much sugar storage; in this case, there is a feedback inhibition on photosynthesis. In other words, in plants with small storage roots, photosynthate is stored until sucrose concentrations become high enough to exert a feedback on photosynthesis in the leaf. This leads to lowered rates of photosynthesis and lower values of  $(F_v)_s$  and  $F_v/F_m$  so that we obtain a negative correlation between sugar concentration and fluorescence values (as in 1994).

We tested this hypothesis in 1996 by carrying out a fluorescence prescreening experiment on two sets of five genotypes, one set with high storage root volumes and the other with low. We selected individual plants with high and low fluorescence values from populations from the two types of genotypes. These selected plants were grown in soil in the greenhouse under the appropriate environmental conditions for optimum growth and sugar production and their root sugar yields and sugar percentage measured as before. Our objective was to prove the hypothesis that selection on the basis of fluorescence will yield superior-yielding genotypes more efficiently in the large-rooted plants than in the small-rooted plants.

## **Materials and Methods**

During the previous years, we sought to optimize the experimental procedure for using pulse-modulated fluorescence to develop new high-yielding genotypes. Our objectives were to: 1) increase the size of the selection sample as well as that of the total population screened, 2) to provide growing conditions which minimized competition between plants for light and nutrients, and 3) to increase the length of time between fluorescence measurement and harvesting (particularly for root sugar content). The greenhouse experiments permitted us to increase the sample size of population screened, and to increase illumination and mineral nutrient supply.

During the past year we continued to carry out experiments inside a computer-controlled greenhouse which maintains temperatures and irradiance within certain limits. Plants were grown in a single controlled environment and illuminated with high light intensities. The fluorescence measurements were carried out under greenhouse daylight conditions using special adapters to dark-adapt portions of the intact leaves *in situ* before measuring fluorescence emission under daylight illumination.

Seeds of two populations (5 different genotypes for each population) of sugar beet with different root volume were obtained from Van der Have Research, The Netherlands. The seeds were sown on July 1-5, 1996 in soil and placed in a controlled environment greenhouse at 25°C with a minimum photon flux density of  $1000 \mu\text{mol m}^{-2} \text{s}^{-1}$  supplied over a 16-hour day. After four weeks, 50 uniform germinated seedlings from each seedlot were selected for the fluorescence analysis. The seedlings were watered daily with half strength Hoagland's solution.

Chlorophyll fluorescence of the attached leaves was measured using the pulse modulation chlorophyll fluoremeter Model PAM 101 (H. Walz, Effeltrich, FRG) (for details see last year's report). Plants to be measured on a certain day were placed in a dark section of the greenhouse. One plant at a time was placed in the light for two hours, then the most rapidly expanding attached leaf was dark-adapted with a special adapter and the fluorescence measurements made. At the end of the fluorescence measurement period (July 29-Aug. 3), the 30 plants exhibiting the highest values and the 30 plants with the lowest values of each of two fluorescence parameters were selected and transferred into larger plastic pots containing the same potting medium (one plant only per pot). This year's selection was based on two different values of  $F_v/F_m$  depending on the method of calculation of the  $F_v$  value. In the first method,  $F_v$  was calculated as the difference between the  $F_m$  and  $F_o$  values. While in the second method,  $F_v$  was calculated as described by Schreiber (1986) where  $F_v = F_m - (F_o + q.(F_v)_m)$ . For the purpose of clarity we will call the first ratio as "true  $F_v/F_m$ " and the second ratio as "Schreiber  $F_v/F_m$ " throughout this report.

All the selected plants (110 plants) were allowed to grow in pots in the greenhouse until maturity. All plants, which were initially arranged randomly, were re-randomized at weekly intervals to minimize environmental variation. After approximately another one

month, the plants were harvested (Sept 4-6, 1996). At harvest, all plants were separated to shoots and roots, sugar content measured in storage roots, and total fresh and dry weights recorded. These results were then subjected to statistical analyses to test for significant correlations between the fluorescence parameters and sugar yield of the two populations, i.e., to determine whether the root size has any feedback inhibition effect on the photosynthetic efficiency of the sugar beet plants and in turn on their ability to store in their roots.

## Results

This year's experiment was not completed as it was planned due to time and greenhouse space limitations and the selected plants were harvested only after one month from selection. The plants were supposed to be grown for at least two months from selection. Although, the experiment was started late in the summer (July 1), we had to terminate it by the first week of September. The roots were therefore substantially small at harvest and the total sugar yield did not exceed 10 g per plant in most cases (with some plants attaining less than one gram per plant). In addition, the selection was based on two forms of the  $F_v/F_m$  parameter as described in the materials and methods and the  $F(v)s$  parameter was not used for the selection as it was originally planned. This is because we needed to compare between selecting for the real  $F_v/F_m$  (see Materials and Methods), the form that most researchers use and that we used in our early work, and the Schreiber  $F_v/F_m$  (see Materials and Methods), the form that is recently proposed by Schrieber and that we used in our most recent work.

Due to the above mentioned setbacks we were not able to fully test our hypothesis that selection on the basis of fluorescence will yield superior-yielding genotypes more efficiently in the large-rooted plants than in the small-rooted plants. The results we obtained show little differences in the amount and percentage of sugar between the plants

selected for high and those selected for low Fv/Fm (Figs. 1 and 2). Even when the results of the small-rooted and large rooted plants were analysed separately (Figs. 3-6), no significant correlations were found between fluorescence measurements and storage root sugar content or yield except between Schreiber Fv/Fm and sugar yield of the small-rooted plants (Fig. 4b).

However, when the five plants with the highest sugar content were compared with the five plants with the lowest sugar content in each of the two sugar beet genotype groups (small-rooted genotypes and large rooted genotypes), we found that the average values of the fluorescence measurements made on these plants at three weeks from sowing differed substantially between the two sets of plants especially for F(v)s (Table 1). For example, the five plants with the highest sugar content of the small-rooted plants had an average F(v)s value of 79.6 while those with the lowest sugar content had an average value of 57.8. In the large-rooted genotypes, the five plants with the highest sugar content had an average F(v)s value of 86.8 while those with the lowest sugar content had an average value of 67. Similar, but less substantial, results were observed for other fluorescence parameters (i.e., true Fv/Fm, Schreiber Fv/Fm, Fv, qQ, qE). These data

Table 1: Average values of some important fluorescence parameters of the five sugar beet plants with the highest sugar content compared to those with the lowest sugar content of the small-rooted and large-rooted genotype groups.

Genotype	Sugar (%)	Sugar (g/plant)	Schreiber Fv/Fm	True Fv/Fm	F(v)s	Fv	qQ	qE
Small root/ high Sugar	11.1 ± 0.25	7.67 ± 1.12	0.171 ± 0.07	0.771 ± 0.03	79.6 ± 18.3	97.0 ± 21.5	58.8 ± 8.70	17.4 ± 5.03
Small root/ low Sugar	6.58 ± 0.99	2.66 ± 1.46	0.145 ± 0.07	0.732 ± 0.06	57.8 ± 11.7	74.2 ± 12.5	43.5 ± 8.34	16.3 ± 9.89
Large root/ high Sugar	9.72 ± 1.02	8.48 ± 1.78	0.224 ± 0.05	0.782 ± 0.02	86.8 ± 10.3	109.6 ± 12.3	53.6 ± 7.70	23.4 ± 5.59
Large root/ low Sugar	5.04 ± 0.52	2.4 ± 0.64	0.239 ± 0.01	0.791 ± 0.03	67.0 ± 12.8	85.4 ± 15.5	44.0 ± 5.39	18.4 ± 10.1

illustrate that there is a clear difference in the fluorescence characteristics between superior-yielding and low yielding individual sugar beet plants. If F(v)s was included in the parameters used for the selection and the selected plants were allowed to grow for another 4-6 weeks before harvest we might have obtained more significant correlations between the fluorescence and yield parameters.

## Conclusions

Despite the setbacks of the experimental procedure and the deviation from the planned procedure, we were still able to observe substantial differences between the fluorescence measurements made on plants that yielded high sugar content compared to those yielded low sugar content in the storage root. However, our hypothesis that selection on the basis of fluorescence will yield superior-yielding genotypes more efficiently in the large-rooted plants than in the small-rooted plants was not fully tested in this experiment and a future experiment will have to be carried out before a final conclusion can be reached.

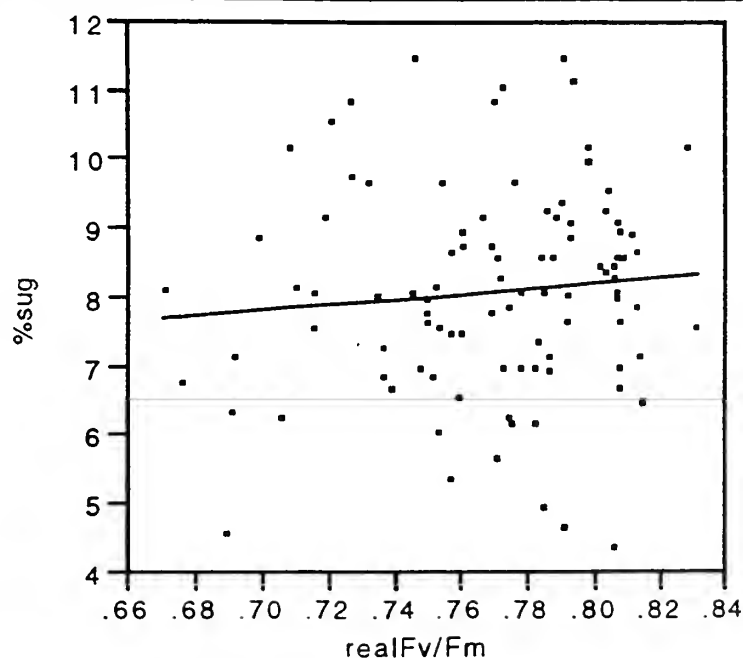
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# %sug By realFv/Fm



— Linear Fit

## Linear Fit

$$\%sug = 5.14735 + 3.84817 \text{ realFv/Fm}$$

## Summary of Fit

RSquare	0.008499
RSquare Adj	-0.00183
Root Mean Square Error	1.504045
Mean of Response	8.106633
Observations (or Sum Wgts)	98

## Analysis of Variance

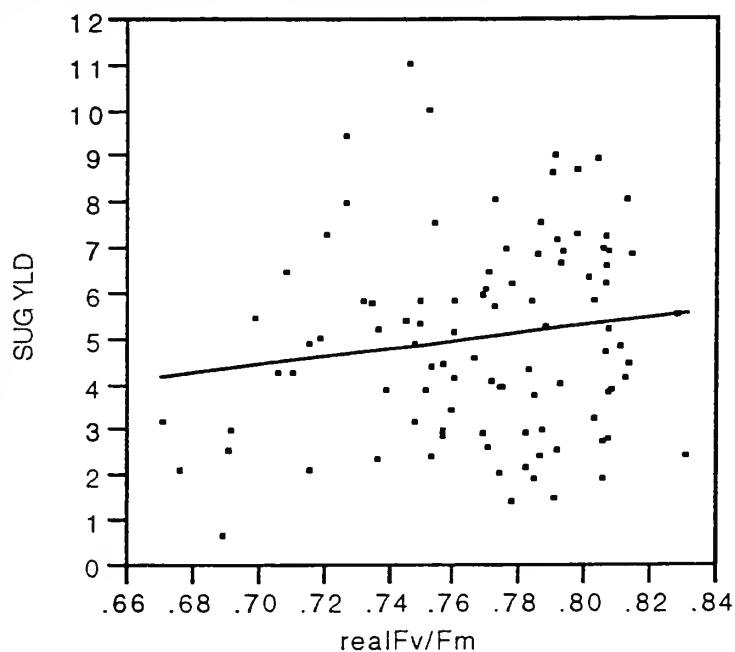
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.86163	1.86163	0.8229
Error	96	217.16656	2.26215	<b>Prob&gt;F</b>
C Total	97	219.02819		0.3666

## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	5.1473454	3.265671	1.58	0.1183
realFv/Fm	3.8481725	4.241987	0.91	0.3666

Fig. 1(a): Relationship between **true Fv/Fm** values measured on 3 weeks old seedlings and storage root **sugar percentage**.

## SUG YLD By realFv/Fm



— Linear Fit

### Linear Fit

$$\text{SUG YLD} = -1.5558 + 8.6026 \text{ realFv/Fm}$$

### Summary of Fit

RSquare	0.020843
RSquare Adj	0.010643
Root Mean Square Error	2.133713
Mean of Response	5.059721
Observations (or Sum Wgts)	98

### Analysis of Variance

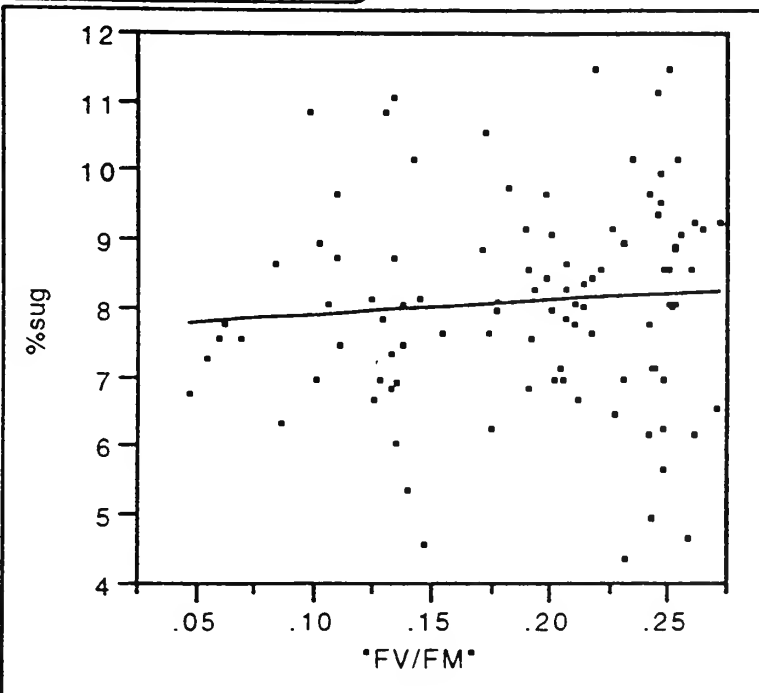
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	9.30342	9.30342	2.0435
Error	96	437.06226	4.55273	<b>Prob&gt;F</b>
C Total	97	446.36569		0.1561

### Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-1.555775	4.632843	-0.34	0.7377
realFv/Fm	8.602602	6.017893	1.43	0.1561

Fig. 1(b): Relationship between **true Fv/Fm** values measured on 3 weeks old seedlings and storage root **sugar yield (g/plant)**.

# %sug By "FV/FM"



— Linear Fit

## Linear Fit

$$\%sug = 7.72861 + 2.06876 \text{ *FV/FM*}$$

## Summary of Fit

RSquare	0.006522
RSquare Adj	-0.00276
Root Mean Square Error	1.498086
Mean of Response	8.127523
Observations (or Sum Wgts)	109

## Analysis of Variance

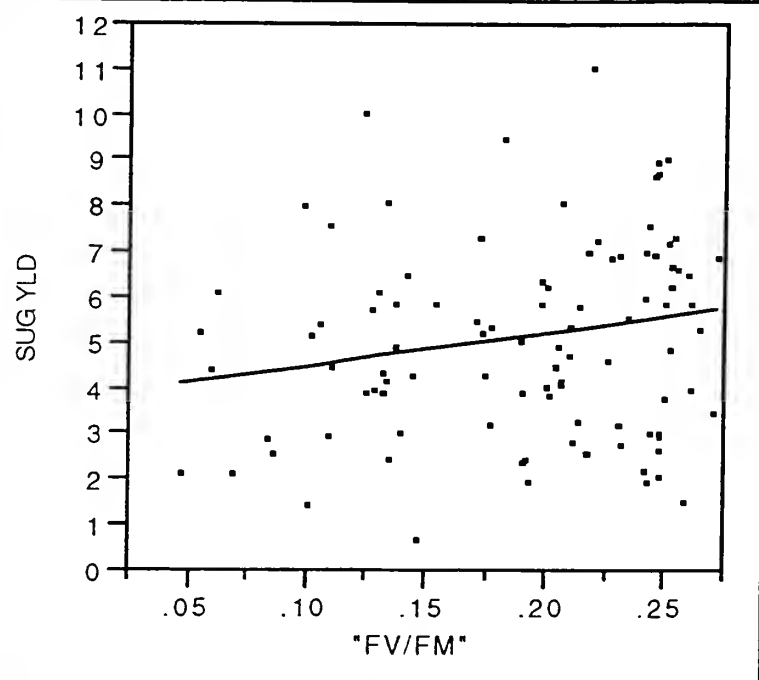
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.57637	1.57637	0.7024
Error	107	240.13606	2.24426	<b>Prob&gt;F</b>
C Total	108	241.71243		0.4038

## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	7.7286088	0.497137	15.55	<.0001
*FV/FM*	2.0687598	2.468413	0.84	0.4038

Fig. 2(a): Relationship between **Schrieber Fv/Fm** values measured on 3 weeks old seedlings and storage root **sugar percentage**.

# SUG YLD By "FV/FM"



— Linear Fit

## Linear Fit

$$\text{SUG YLD} = 3.76865 + 7.40682 \text{ "FV/FM"}$$

## Summary of Fit

RSquare	0.037683
RSquare Adj	0.028689
Root Mean Square Error	2.19608
Mean of Response	5.196894
Observations (or Sum Wgts)	109

## Analysis of Variance

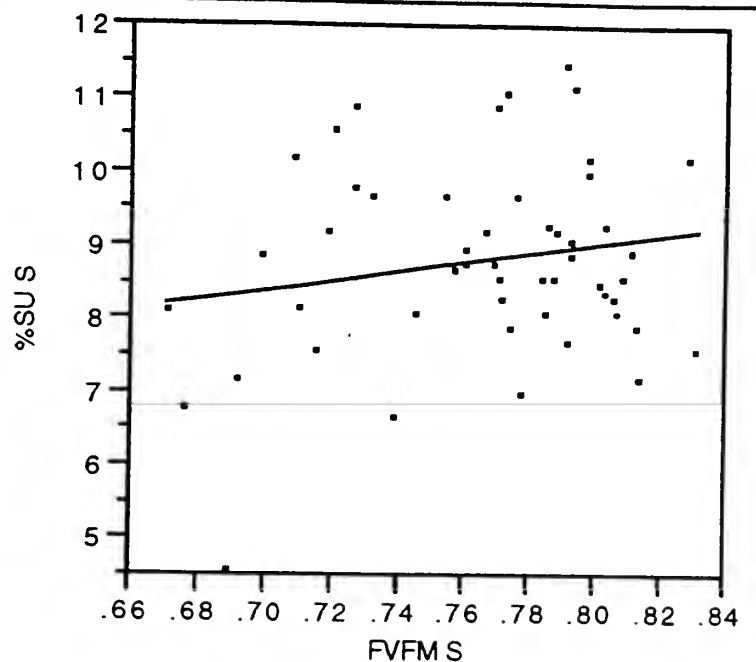
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	20.20701	20.2070	4.1899
Error	107	516.03621	4.8228	<b>Prob&gt;F</b>
C Total	108	536.24322		0.0431

## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.7686537	0.728765	5.17	<.0001
"FV/FM"	7.4068248	3.618505	2.05	0.0431

Fig. 2(b): Relationship between Schrieber Fv/Fm values measured on 3 weeks old seedlings and storage root sugar yield (g/plant).

# **%SU S By FVFM S**



— Linear Fit

## **Linear Fit**

$$\%SU S = 3.9579 + 6.34433 FVFM S$$

## **Summary of Fit**

RSquare	0.039415
RSquare Adj	0.019811
Root Mean Square Error	1.295223
Mean of Response	8.819608
Observations (or Sum Wgts)	51

## **Analysis of Variance**

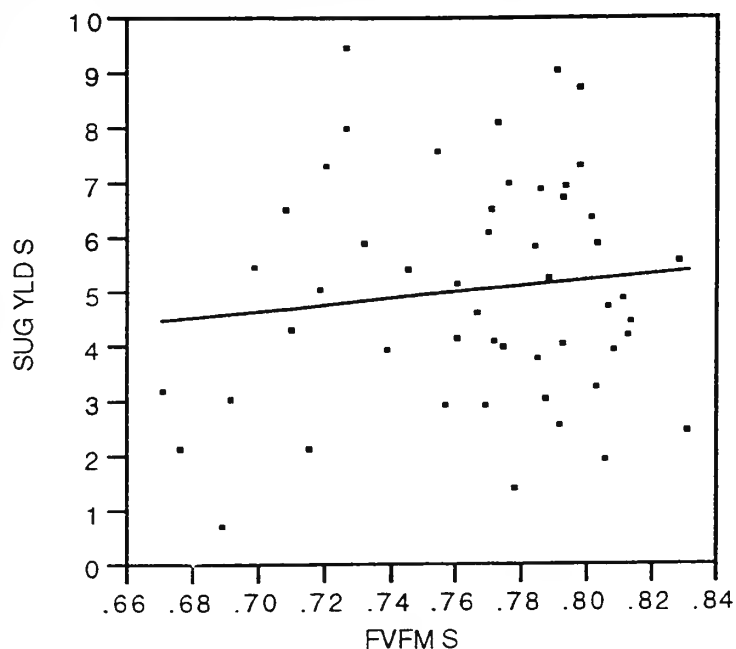
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.372925	3.37292	2.0106
Error	49	82.202467	1.67760	<b>Prob&gt;F</b>
C Total	50	85.575392		0.1625

## **Parameter Estimates**

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.9578956	3.4335	1.15	0.2546
FVFM S	6.3443331	4.47432	1.42	0.1625

Fig. 3(a): Relationship between true Fv/Fm values measured on 3 weeks old seedlings and storage root **sugar percentage of the small-rooted genotypes**.

### SUG YLD S By FVFM S



— Linear Fit

### Linear Fit

$$\text{SUG YLD S} = 0.62211 + 5.76439 \text{ FVFM S}$$

### Summary of Fit

RSquare	0.013225
RSquare Adj	-0.00691
Root Mean Square Error	2.059114
Mean of Response	5.039409
Observations (or Sum Wgts)	51

### Analysis of Variance

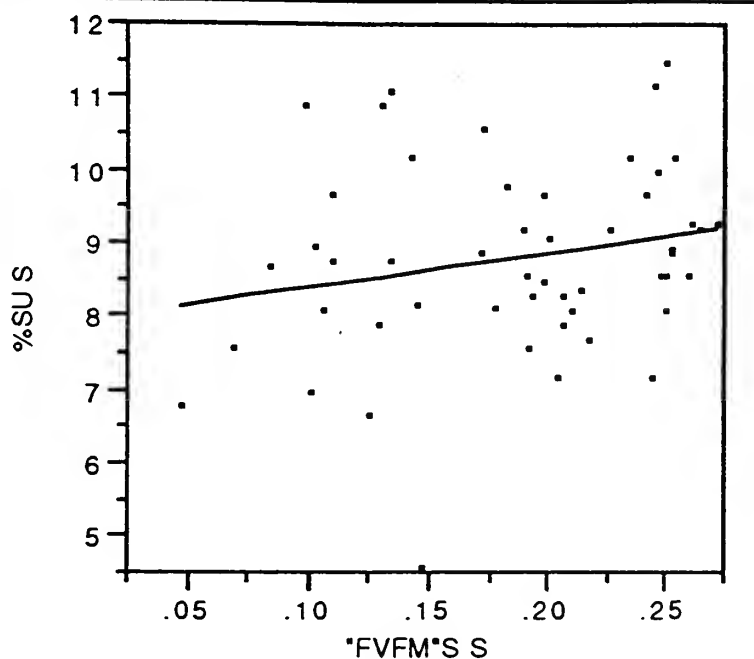
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.78446	2.78446	0.6567
Error	49	207.75756	4.23995	<b>Prob&gt;F</b>
C Total	50	210.54202		0.4216

### Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.62211	5.458497	0.11	0.9097
FVFM S	5.7643921	7.113167	0.81	0.4216

Fig. 3(b): Relationship between **true Fv/Fm** values measured on 3 weeks old seedlings and storage root **sugar yield (g/plant)** of the *small-rooted genotypes*.

# %SU S By "FVFM"S S



— Linear Fit

## Linear Fit

$$\%SU S = 7.93192 + 4.77312 *FVFM*S S$$

## Summary of Fit

RSquare	0.047972
RSquare Adj	0.028543
Root Mean Square Error	1.28944
Mean of Response	8.819608
Observations (or Sum Wgts)	51

## Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.105217	4.10522	2.4691
Error	49	81.470176	1.66266	<b>Prob&gt;F</b>
C Total	50	85.575392		0.1225

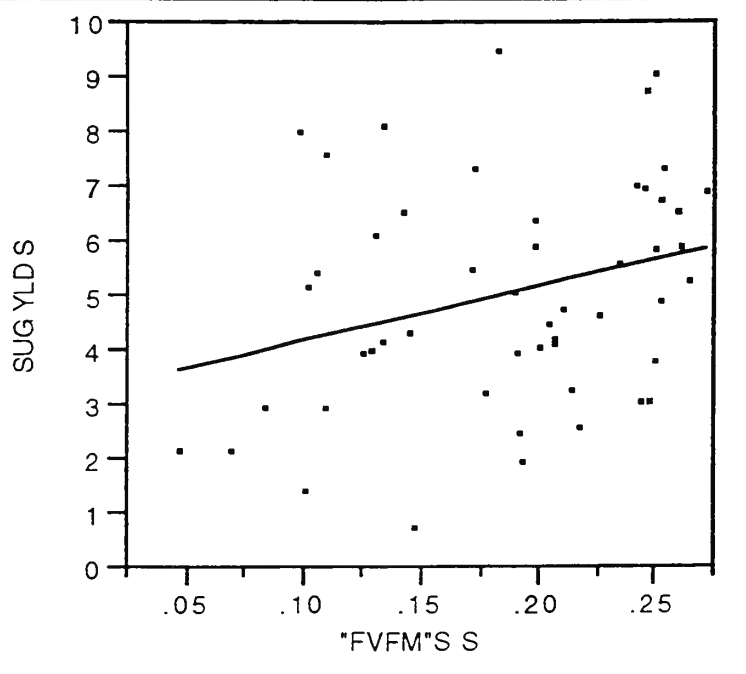
## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	7.9319178	0.593083	13.37	<.0001
*FVFM*S S	4.7731226	3.037637	1.57	0.1225

Fig. 4(a): Relationship between Schrieber Fv/Fm values measured on 3 weeks old seedlings and storage root sugar percentage of the small-rooted genotypes.



# SUG YLD S By "FVFM"S S



— Linear Fit

## Linear Fit

$$\text{SUG YLD S} = 3.18512 + 9.97053 \text{ "FVFM"S S}$$

## Summary of Fit

RSquare	0.08508
RSquare Adj	0.066408
Root Mean Square Error	1.982727
Mean of Response	5.039409
Observations (or Sum Wgts)	51

## Analysis of Variance

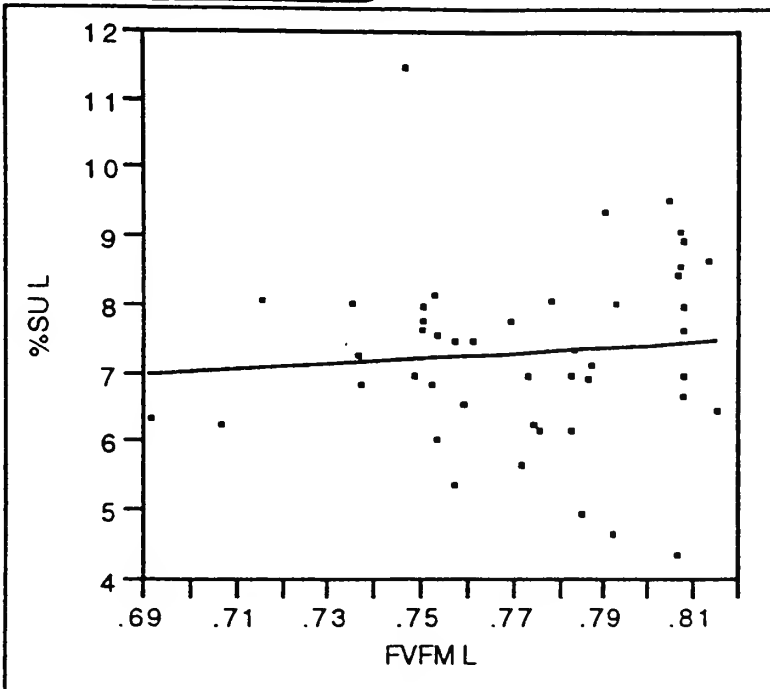
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	17.91295	17.9130	4.5566
Error	49	192.62907	3.9312	<b>Prob&gt;F</b>
C Total	50	210.54202		0.0378

## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	3.1851219	0.911962	3.49	0.0010
"FVFM"S S	9.9705279	4.670866	2.13	0.0378

Fig. 4(b): Relationship between Schrieber Fv/Fm values measured on 3 weeks old seedlings and storage root sugar yield (g/plant) of the small-rooted genotypes.

# **%SU L By FVFM L**



## **Linear Fit**

$$\%SU L = 4.38548 + 3.81828 FVFM L$$

## **Summary of Fit**

RSquare	0.007554
RSquare Adj	-0.0145
Root Mean Square Error	1.323267
Mean of Response	7.332979
Observations (or Sum Wgts)	47

## **Analysis of Variance**

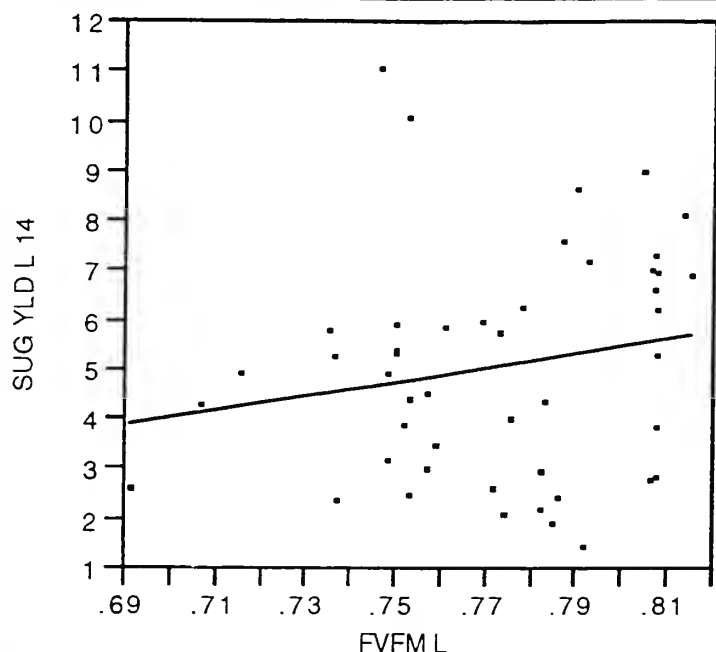
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.599769	0.59977	0.3425
Error	45	78.796614	1.75104	<b>Prob&gt;F</b>
C Total	46	79.396383		0.5613

## **Parameter Estimates**

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	4.3854813	5.039966	0.87	0.3888
FVFM L	3.818277	6.524134	0.59	0.5613

Fig. 5(a): Relationship between true Fv/Fm values measured on 3 weeks old seedlings and storage root sugar percentage of the large-rooted genotypes.

# SUG YLD L 14 By FVFM L



— Linear Fit

## Linear Fit

SUG YLD L 14 = -6.0377 + 14.4045 FVFM L

## Summary of Fit

RSquare	0.036203
RSquare Adj	0.014785
Root Mean Square Error	2.24719
Mean of Response	5.081762
Observations (or Sum Wgts)	47

## Analysis of Variance

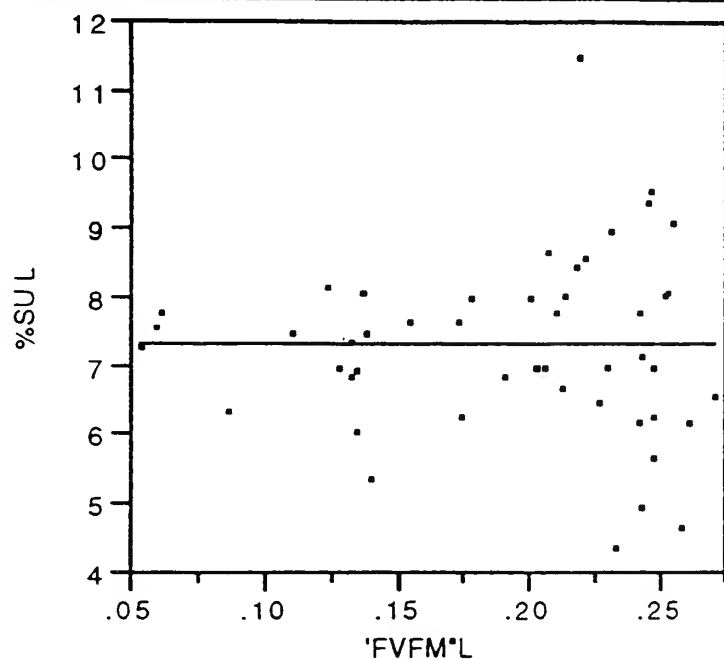
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	8.53586	8.53586	1.6903
Error	45	227.24393	5.04987	<b>Prob&gt;F</b>
C Total	46	235.77979		0.2002

## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-6.037729	8.55894	-0.71	0.4842
FVFM L	14.404523	11.07937	1.30	0.2002

Fig. 5(b): Relationship between **true Fv/Fm** values measured on 3 weeks old seedlings and storage root **sugar yield (g/plant)** of the *large-rooted genotypes*.

# **%SU L By 'FVFM"L**



— Linear Fit

## **Linear Fit**

$$\%SU L = 7.32532 + 0.09047 'FVFM"L$$

## **Summary of Fit**

RSquare	0.000017
RSquare Adj	-0.02172
Root Mean Square Error	1.315531
Mean of Response	7.342708
Observations (or Sum Wgts)	48

## **Analysis of Variance**

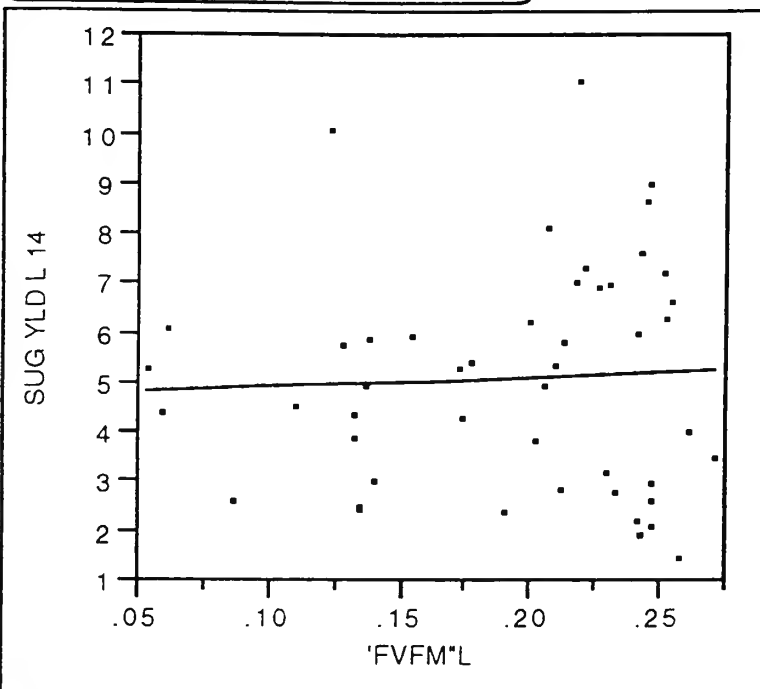
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.001360	0.00136	0.0008
Error	46	79.608588	1.73062	<b>Prob&gt;F</b>
C Total	47	79.609948		0.9778

## **Parameter Estimates**

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	7.3253248	0.648538	11.30	<.0001
'FVFM"L	0.0904726	3.227402	0.03	0.9778

Fig. 6(a): Relationship between Schrieber Fv/Fm values measured on 3 weeks old seedlings and storage root sugar percentage of the large-rooted genotypes.

# SUG YLD L 14 By 'FVFM"L



— Linear Fit

## Linear Fit

SUG YLD L 14 = 4.7716 + 1.72885 'FVFM"L

## Summary of Fit

RSquare	0.002096
RSquare Adj	-0.0196
Root Mean Square Error	2.266854
Mean of Response	5.103779
Observations (or Sum Wgts)	48

## Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.49660	0.49660	0.0966
Error	46	236.37682	5.13863	<b>Prob&gt;F</b>
C Total	47	236.87342		0.7573

## Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	4.7715952	1.117526	4.27	<.0001
'FVFM"L	1.7288497	5.56129	0.31	0.7573

Fig. 6(b): Relationship between storage root **sugar yield (g/plant)** of the *large rooted genotypes* and **Schrieber Fv/Fm** values measured on 3 weeks old seedlings.

# **SUGARBEET RESEARCH**

## **1996 REPORT**

### **Section B**

Crops Research Laboratory, Agricultural Research Service  
U.S. Department of Agriculture, Fort Collins, Colorado

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Dr. Susan S. Martin, Plant Physiologist  
Dr. Lee Panella, Geneticist

Cooperation:

Colorado Agricultural Experiment Station

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(Projects 440, 441, 442, 903, and 904)



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**ABSTRACTS & GERMPLASM REGISTRATIONS**

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\*PANELLA, L. and E.G. RUPPEL. Availability of germplasm for resistance against *Rhizoctonia* spp. pp. 515-527 In: (eds. B. Sneh, S. Jabji-Hare, S. Neate & G. Oijst) *Rhizoctonia* species: Taxonomy, Molecular Biology, Ecology, Pathology and Control. Kluwer academic publishers, Dordrecht. 1996.

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\*PANELLA, L., C. E. WINDELS, and E. G. RUPPEL. 1997. Sugarbeet germplasm with resistance to *Rhizoctonia* effective against several pathogenic isolates of *Rhizoctonia solani* AG-2-2. J. Sugar Beet Res. (ASSBT Meeting 3/2 - 3/5, 1997) (Abstract).

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\*Abstract is included on the following pages.

Screening and utilizing Beta genetic resources with resistance to Rhizoctonia root rot and Cercospora leaf spot in a sugar beet breeding program. Lee Panella, USDA-ARS Research Geneticist

The United States Department of Agriculture - Agricultural Research Service has had a sugarbeet (*Beta vulgaris* L.) breeding program at Fort Collins, CO for about 70 years. During that time, this program has provided the sugarbeet seed industry with germplasm having excellent resistance to Rhizoctonia root rot (caused by *Rhizoctonia solani*) and Cercospora leaf spot (caused by *Cercospora beticola*). This germplasm has been developed by mass selection and recurrent mass selection techniques in nurseries in which artificial epiphytotics of these diseases have been created. Because of the higher heritability of genetic resistance to Rhizoctonia root rot, a higher level of resistance is seen in sugarbeet germplasm to this disease than to Cercospora leaf spot. Much diverse germplasm has been screened to find new and varied sources of resistance to these diseases. Because of the difficulties in evaluating the disease resistance of annual wild beet germplasm (*Beta vulgaris* ssp. *maritima* and other wild relatives), this germplasm has not been utilized as often as germplasm with a biennial reproductive system. To find additional sources of host plant resistance and create a more diverse genetic base in our resistant germplasm, especially in resistance to Cercospora leaf spot, we need to find better ways to screen and incorporate annual wild beet germplasm into the commercial gene pool.

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Panella, L.<sup>1</sup>, S. Mitchell<sup>2</sup>, C. Jester<sup>2</sup>, R. Dean<sup>2</sup>, E.G. Ruppel<sup>1</sup> and S. Kresovich<sup>2</sup>, USDA Agricultural Research Service, <sup>1</sup>Sugarbeet Research Unit, 1701 Center Ave., Fort Collins, CO 80526, <sup>2</sup>Plant Genetic Resources Conservation Unit, University of Georgia, Griffin, GA 30223. Determination of genetic relationships among isolates of *Rhizoctonia solani* Kühn based on DNA sequence.

Understanding the genetic relationships among different isolates of a plant pathogen is a necessary prerequisite to understanding the interaction between that pathogen and the host plant. Sequence data from 75 isolates of *Rhizoctonia solani* were used to develop a phylogeny, with emphasis on anastomosis group (AG) 2-2, which contains isolates pathogenic to sugarbeet. The internal transcribed spacers and 5.8S rDNA gene were sequenced with an Perkin-Elmer/Applied Biosystems model 377® automated sequencer. The sequencing reaction was PCR-based and used primers flanking the large and small nuclear rDNA genes, as well as internal primers on the 5.8S rDNA gene. The neighbor joining method was used to construct a phylogenetic tree. There was agreement between the phylogenetic grouping and anastomosis grouping. The four isolates that were originally grouped by sequence data outside their anastomosis group were found to have been assigned to the wrong anastomosis group when retested. Distinct subgroups within anastomosis group also were delineated. There were two groups within AG-1 one containing isolates from the U.S. and one containing isolates from Japan. Subgroups AG-2-2IIIB and AG-2-2IV also were distinctly grouped within AG-2-2. It is also hoped that unique sequences can be found that are diagnostic of anastomosis group and specifically of the sugarbeet pathogenic isolates within AG-2-2. This research increased our understanding of the genetic relationships among the anastomosis groups of this important plant pathogen.

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Panella, L. and E.G. Ruppel. Availability of germplasm for resistance against *Rhizoctonia* spp. pp. 515-527 In: (eds. B. Sneh, S. Jabji-Hare, S. Neate & G. Oijst) *Rhizoctonia* species: Taxonomy, Molecular Biology, Ecology, Pathology and Control. Kluwer academic publishers, Dordrecht. 1996.

This book chapter reviews the availability of germplasm providing resistance to *Rhizoctonia* spp. across plant species. Farr and co-workers list over 500 genera of plants in *Fungi on Plants and Plant Products in the United States* that are hosts to *Rhizoctonia solani* Kühn and 21 other possible species of *Rhizoctonia* that are phytopathogenic. Agricultural, horticultural, and ornamental, and some tree species are affected. Twenty-five years ago, Leach and Garber reviewed the subject of resistance to *Rhizoctonia* infection and concluded, "In general, while it has been possible to identify differences among cultivars or selections in susceptibility to *Rhizoctonia* infection, it is extremely rare that a high degree of resistance has been found or produced by selection or breeding within a susceptible host species." There is an increasing number of plant species in which selection has provided germplasm with resistance to diseases caused by *Rhizoctonia* spp. In most cases, the resistance is not immunity, but rather an ability of the host plant to continue growth in the presence of the pathogen. A survey of *Crop Science* revealed a list of 59 cultivar, parental line, and germplasm registrations in nine crop species during last 10 years that have some resistance to diseases caused by *Rhizoctonia* spp. These are listed with cultivar releases from other sources. All of this information attests to the importance of germplasm with resistance to *Rhizoctonia* spp.

In a few crops, genetic control of this resistance has been studied. With few exceptions, resistance is governed by more than one gene. In the two crop species where single-gene resistance is hypothesized, resistance was due to toughness of the fruit epidermis, thereby providing a mechanical resistance to infection.

Host plant resistance to *Rhizoctonia* has proved durable in many crop species. As regulation of chemical control becomes more stringent, increasing resistance, coupled with sound management practices, will become an even more important method for managing plant diseases caused by *Rhizoctonia* spp. Strong host plant resistance will allow continued food and fiber production in areas where *Rhizoctonia* is present.

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Panella, L. and E. G. Ruppel. 1996. **Notice of Release of FC721 and FC721CMS Sugarbeet Germplasms.** United States Department of Agriculture Agricultural Research Service, Washington, DC and Beet Sugar Development Foundation, Denver, Colorado.

SUGARBEET (*Beta vulgaris* L.) germplasms FC721 (Reg. no. GP- , PI 594910 ) and FC721CMS (Reg. no. GP- , PI 594911 ) were developed by the USDA-ARS in cooperation with the Beet Sugar Development Foundation. They were released in 1996 from seed productions 931005HO and 931005HO1. These germplasms were released as sources of resistance to root-rotting strains of *Rhizoctonia solani* Kühn and incorporate moderate tolerance to the curly top virus and leaf spot caused by *Cercospora beticola* Sacc.

FC721 is a diploid, monogerm, O-type, self-fertile ( $S^f$ ), sugarbeet germplasm resistant to root and crown rot caused by *R. solani* AG-2-2. It is relatively homogenous, easy bolting, and moderately tolerant to the curly top virus and *Cercospora* leaf spot caused by *Cercospora beticola* Sacc. FC721 segregates for hypocotyl color (39% *rr*) and genetic male sterility (*aa*). It is the O-type (maintainer

line) of its CMS equivalent, FC721CMS, which is the BC<sub>10</sub> with C718CMS as the nonrecurrent parent.

One parental component of FC721 was a population developed from selected S<sub>1</sub> plants crossed to FC701. The S<sub>1</sub> progeny were from populations that had been developed (in the early 1950s), selected, recombined, and reselected from a number of curly top and leaf spot resistant sources that included SLC122-0, US 22/3, US 22/4 US 201, SL 202, and US 35/2. The parent derived from these S<sub>1</sub> selections x FC701 segregated for genetic male sterility. Twenty-three male-sterile plants were pollinated by 13 fertile plants from C718 to produce the F<sub>1</sub> from which FC721 was selected. C718 from the USDA-ARS sugarbeet breeding program in Salinas, CA is bolting resistant, moderately resistant to curly top, and has good combining ability for root and sucrose yield. The female parent combined sources of resistance to *Rhizoctonia* root rot, *Cercospora* leaf spot, and curly top virus.

F<sub>2</sub> plants were selfed in the greenhouse and O-type indexed. Twenty-five O-type, S<sub>1</sub> plants were bulk increased in the greenhouse. The resulting population underwent five cycles of mass selection for resistance to *Rhizoctonia* root rot concurrent with three cycles of mass selection for monogerm seedballs. The smallest population size during this selection process was nine plants.

In a 1994 replicated field evaluation for resistance to *R. solani* at Fort Collins, CO, FC721 and FC721CMS were not significantly different from each other or from the resistant check, but were significantly more resistant than the susceptible check. FC721 and FC721CMS had mean disease indices (DIs) of 1.8 and 2.3, compared with 1.8 and 4.9 for the resistant (FC703) and susceptible (FC901/C817//413) checks, respectively (DI of 0 = no root rot and 7 = all plants dead). Percentages of resistant plants (those rated 0 or 1) were 36, 36, 60, and 5 for FC721, FC721CMS, and the resistant and susceptible checks. The 1994 epiphytotic was severe and an excellent test of resistance to *Rhizoctonia* root rot. In the more moderate 1995 epiphytotic, DIs of 1.7, 1.7, 1.8, and 3.4 for FC721, FC721CMS, resistant, and susceptible checks were obtained. Percentages of healthy plants (those rated 0 or 1) were 45, 43, 58 and 7 for FC721, FC721CMS, resistant check, and susceptible check, respectively.

FC721 and FC721CMS were tested in 1994 and 1995 in the Beet Sugar Development Foundation's curly top nursery in Kimberly, ID. Under the severe epiphytotic of 1994, FC721 and FC721CMS performed intermediately -- significantly poorer than the resistant control (Beta G6040), but significantly better than the susceptible control (FC718). FC721 and FC721CMS had mean DIs of 7.2 and 6.8, compared with 5.2 and 8.3 for the resistant and susceptible checks, respectively [Mumford's classification: 0 (= healthy) to 9 (= plant dead)]. In the more moderate 1995 epiphytotic, FC721 was not significantly different from the resistant check and FC721CMS was intermediate. FC721 and FC721CMS had mean DIs of 4.3 and 4.7, compared with 3.8 and 6.3 for the resistant and susceptible checks (L609), respectively.

FC721 and FC721CMS also show some resistance to *Cercospora* leaf spot when tested in an artificial epiphytotic. When tested in the mild epiphytotic of 1994, they were not significantly better than the susceptible control (SP351069-0) or significantly different from the resistant control (FC504CMS/FC502-2//SP6322-0). In 1995, which was more severe than 1994, FC721 and FC721CMS were intermediate in resistance (significantly different from both resistant and susceptible controls) with mean DIs of 4.5 and 4.7, compared with 3.5 and 6.2 for the resistant and susceptible checks (L609), respectively.

General combining ability of FC721 has not been tested. FC721 is proposed for use as an O-type population with multiple disease resistance, from which to select O-type monogerm parents for

use in commercial three-way resistant hybrids.

Seed of FC721 and its CMS equivalent is maintained by the USDA-ARS and will be provided in quantities sufficient for reproduction upon written request to the corresponding author. We request that an appropriate recognition be made of the source when this germplasm contributes to the development of a new cultivar.

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Panella, L.<sup>1</sup> and C. R. Smith<sup>2</sup>, <sup>1</sup>USDA, Agricultural Research Service, 1701 Center Ave., Fort Collins, CO 80526 and <sup>2</sup>Summit Plant Laboratories, Inc., 2301 Research Blvd., Suite 106, Ft. Collins, CO 80526. An example of government-industry partnering in which both sides benefit.

The USDA Cooperative Research and Development Agreement (CRADA) provides a framework for cooperation that protects the interests of the Agricultural Research Service researcher and industry collaborator. The Sugarbeet Research Unit in Fort Collins has a CRADA with Summit Plant Laboratories, Inc. (SPL) to optimize production of clonally propagated sugarbeets. There are many research and breeding uses for sugarbeet clones, including: 1) production of hybrid seed for combining ability tests, 2) minimization of space needed to maintain genotypes undergoing progeny (or clonal) testing, 3) identical genotypes for research experiments, and 4) to archive unique genotypes over time. However, the production of tissue culture-derived clones requires expensive facilities and trained personnel, and even labs that do tissue culture research often are not designed to produce, economically, sufficient clones for field testing. SPL provides plant propagation services and products via laboratory and greenhouse technologies, and specializes in large scale production of elite, disease-indexed planting stocks. The development of new or improved techniques and new plant products is essential to remain competitive and profitable as a small business. Collaboration with USDA-ARS provides access to expertise and research capabilities that exceed R & D resources available within the company. For SPL, this CRADA has resulted in: 1) a reliable protocol to clonally propagate sugarbeets that can be offered as a new service/product; 2) a product development model, which estimates costs and times lines when entering new markets; 3) training of technicians in designing and reporting experiments; and 4) exposure in private and public sectors as a vendor of propagation services. For ARS, and other public and private researchers who do not have access to the facilities necessary to produce clonal material on a research or production scale, this CRADA provides access to a commercial source of sugarbeet clones.

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Panella, Lee<sup>1</sup>, Carol E. Windels<sup>2</sup>, and Earl G. Ruppel<sup>1</sup>. <sup>1</sup> USDA, Agricultural Research Service, 1701 Center Ave., Fort Collins, CO 80526 and <sup>2</sup>Northwest Experiment Station, University of Minnesota, Crookston, MN 56716. Sugarbeet germplasm with resistance to *Rhizoctonia* effective against several pathogenic isolates of *Rhizoctonia solani* AG-2-2.

The USDA program at Fort Collins has released sugarbeet germplasm with resistance to *Rhizoctonia* root and crown rot to the sugarbeet seed industry for over 30 years. Germplasm has been screened in the field by creating artificial epiphytotics with a pathogenic isolate of *Rhizoctonia solani* AG-2-2 (R-9). Isolates of *R. solani* AG-2-2 vary in virulence, and the concern has been raised whether *Rhizoctonia*-resistant germplasm withstands other highly virulent isolates. The objective of this study was to compare *Rhizoctonia*-resistant germplasm inoculated with *R. solani* AG-2-2 isolate R-9 (the Colorado standard) and four isolates of AG-2-2 that are very virulent on sugarbeet in Minnesota. In 1995, germplasm (six entries resistant to *Rhizoctonia* and a susceptible check) were

evaluated in field trials at Fort Collins, CO and Crookston, MN. Crowns of 9- to 10-wk-old plants were inoculated with *R. solani* grown on barley grains that had been dried and ground. Roots were evaluated on a 0-7 scale (0=healthy, 7=plant dead) in September (CO) and October (MN). When the *Rhizoctonia*-susceptible entry was excluded from the ANOVA, there were no interactions among germplasm and isolates of *R. solani* AG-2-2 at either location. *Rhizoctonia*-resistant germplasm differed significantly ( $P=0.05$ ) in severity of root rot, but followed the same trends at both locations. All isolates of *R. solani* AG-2-2 were equally virulent at both locations. Disease index values averaged across the germplasm entries were 1.4 (CO) and 2.3 (MN) and across isolates of *R. solani* were 1.4 (CO) and 2.5 (MN). Multigenic resistance of the USDA germplasm to *Rhizoctonia* root and crown rot of sugarbeet was stable against the highly virulent isolates of *R. solani* AG-2-2 in both locations.

# **RHIZOCTONIA ROOT ROT RESISTANCE AND DEVELOPMENT OF GENETIC RESISTANCE IN SUGARBEET (BSDF Project 440)**

## **1996 Field Research on Rhizoctonia Root Rot of Sugarbeet.**

L. Panella and E. G. Ruppel.

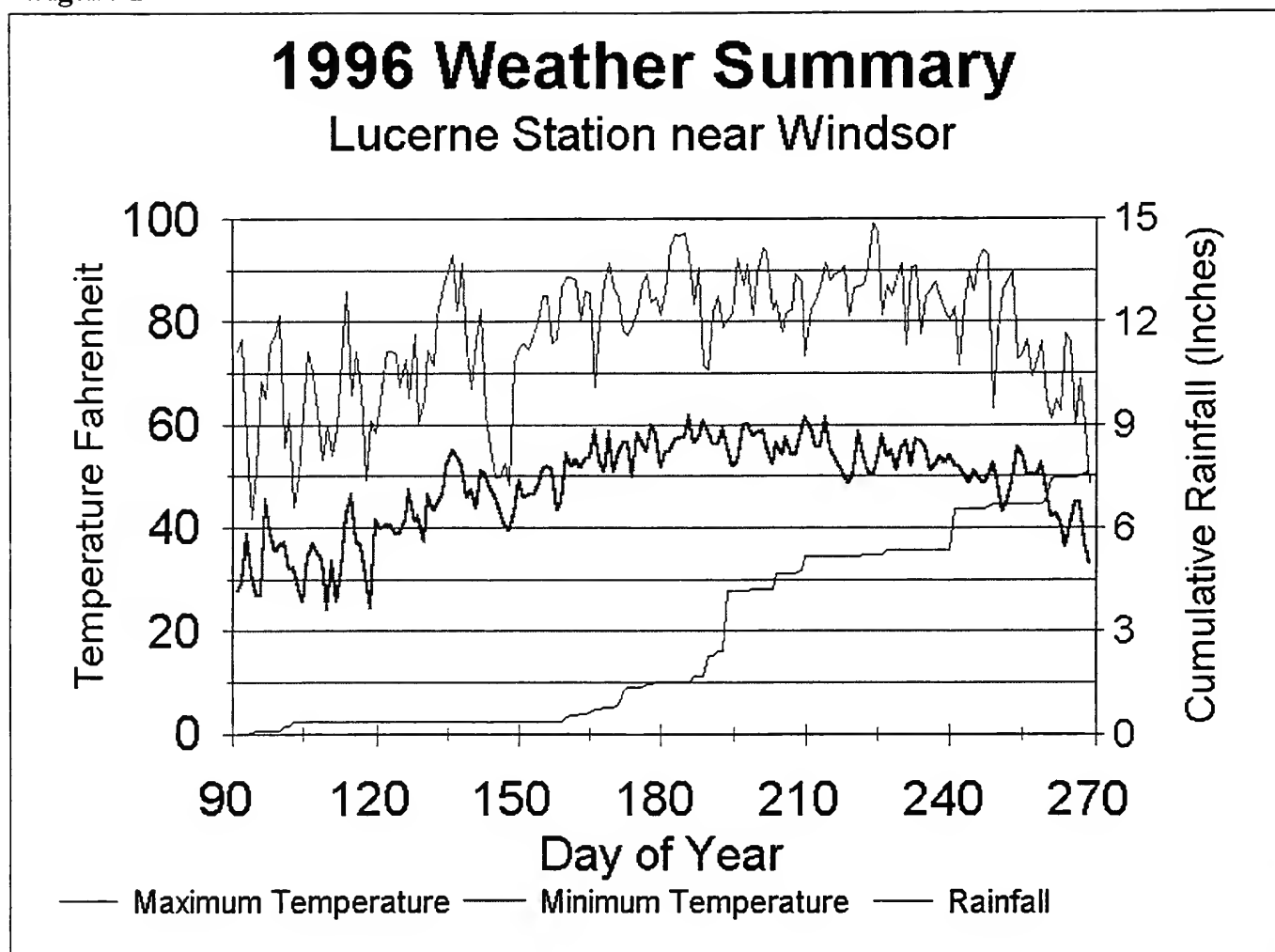
We have been pleased to participate and lead this cooperative research project between the ARS, Colorado State University, and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO. Previously, at our CSU South Farm location, the only cost to ARS was the cost of irrigation water, however, CSU needed the South Farm land for construction purposes, and we were asked to vacate the field plots there. In preparation for the 1996 field season, the land at the Windsor Farm was planted to barley in 1995. Our 1996 field experiments were planted in an area that had been in barley for 1 year, previously having been the site of Dr. Ed Schweizer's weed research program.

Randomized, complete-block designs with five replicates were used to evaluate Fort Collins ARS breeding germplasm. *Rhizoctonia*-resistant line FC703 and highly susceptible FC901/C817//413 were included as internal controls, along with highly resistant FC705-1. One-row plots, planted in mid-May, were 4.3 m (14 feet) long with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* isolate R-9 was performed on July 31; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. Inoculum was moistened and carried into the crowns by overhead sprinkler irrigation, which was applied immediately after inoculation and then intermittently for the next four days. Succeeding irrigations were done by furrow. Before field inoculation, we tested inoculum for virulence on 2-mo-old sugarbeets in the greenhouse; our 1996 inoculum was highly virulent, rotting all inoculated plants. Summer weather was relatively cool and dry (Figure 1).

Beets were harvested during the week of September 23, and each root was rated for rot on a scale of 0 to 7, with 0 = no evidence of rot and 7 = plant dead. Percent healthy roots were those with disease indices (DIs) of 0 and 1, roots with no active infection. Roots with DIs 0 through 3 also were analyzed as a class; these roots were sufficiently sound and large to be recovered in a commercial harvest. ANOVAs were performed on DIs, percent healthy roots, and percentage of harvestable roots. Percentages were transformed to arcsin-square roots to normalize the data for analyses ( $Z\%HLTHY$  and  $Z\%HRVST$  in the accompanying table).



Figure 1



Weather Data was received from Colorado's CoAgMet system, which is electronically reported and can be accessed off of the Colorado Climate Center Webstite at the following URL - <http://ulysses.atmos.colostate.edu/> The Lucerne weather station is located one quarter mile southwest of Lucerne, Colorado (Lat = 40.4753, Lon = 104.7075, elevation = 4750). Our Windsor plots are located about 10 miles west of Lucerne (about Latitude = 40.2730, Longitude = 104.5500, elevation = 4800). The *Cercospora* leaf spot nursery was planted on day 107 (April 17), inoculated on days 179 & 180 (June 28 & 29) and again on day 192 (July 11). Evaluations were made on days 239, 246, and 253 (August 27, September 3 and 10). The *Rhizoctonia* root rot nursery was planted on day 129 (May 9), inoculated on day 212 (July 31) and evaluated on day 266 (September 23).

## Rhizoctonia-Resistant Populations for Multiple Disease Resistance in Sugarbeet

L. Panella.

In a hybrid crop like sugarbeets, it is preferable that all of the parents contain some level of resistance to diseases prevalent in the area in which the hybrid is to be grown. Multiple disease resistance is a difficult goal in a crop improvement program, especially when working with an outcrossing species. In alternating generations of selection, some of the progress made in resistance to one disease is lost while selecting for resistance to other diseases.

One way of solving the problem of selecting for multiple disease resistance is the use of progeny testing. By testing the progeny of individual mother roots, plants with multiple disease resistance can be identified and used as parents of the next generation. The most efficient use of progeny testing is when the genotype of both parents is known, and the easiest way to do this is through self-pollination. In sugarbeet, there is a dominant, self-fertility gene that permits self-pollination. Used in conjunction with genetic male sterility, to insure cross pollination, a system of selfed-family progeny testing can be utilized. Material from the USDA-ARS breeding program at Salinas, CA, has been crossed with some of the Fort Collins lines most resistant to *Rhizoctonia solani* and *Cercospora beticola*. The Salinas material has the self-fertility allele, is segregating for genetic male sterility, and also contains a broad spectrum of resistance to diseases of importance in California as well as other sugarbeet production areas (including rhizomania, powdery mildew, virus yellows, and curly top virus).

Two source populations are being developed. A monogerm population (961008) is segregating for *Rhizoctonia* root rot and other disease resistances, self-fertility, and genetic male sterility. It consists of equal amounts of bulked seed from the crosses, 2890 (sp)/FC708, 2859 m (sp)/FC708. Individual F<sub>2</sub> mother roots from the 1995 field were selfed and the selfed families tested in the BSDF curly top nursery (Table 1). Remnant seed was grown in the greenhouse, and plants from selected families are being bulk-increased in the greenhouse (961027). The resultant seed will be planted in the 1997 Fort Collins *Rhizoctonia* root rot nursery and selected for *Rhizoctonia*-resistance.

A multigerm population was grown in the field at Fort Collins in 1996. It consists of the cross, FC709-2 x 2915 (sp) RZM, and its reciprocal. This population was bulk-increased in the greenhouse in 1995 and was planted in the field in 1996 at Fort Collins. Mother roots harvested from the 1996 field are being selfed in the greenhouse. Selfed families from these plants will be progeny tested in 1997. Selected families will be recombined and further improved.

These populations, together with the materials from Dr. Hecker's program and the populations in the combined *Cercospora* resistance breeding program (from Fargo and Fort Collins), will form the basis of two breeding projects, each containing a strong laboratory component. One will focus on understanding the genetics of the *R. solani*-sugarbeet interaction and producing multiple disease resistance in sugarbeets. The other will focus on understanding the genetics of the *C. beticola*-sugarbeet interaction, and producing strong and stable host plant resistance.

**Table 1. 1996 Curly Top Nursery - Kimberly, ID. Selfed families from the F<sub>2</sub> populations of the crosses 2890 (sp) x FC708 and 2859 m (sp) x FC708. Those lines performing as well or better than the resistant check variety are being increased.**

Designation	Disease Index <sup>1</sup>		Mean
	08/26/96	09/16/96	
	LSD <sup>3</sup>		
961008-5s	3.0	4.5	3.75
961008-14s	3.5	4.5	4.00
961008-24s	3.5	4.5	4.00
961008-9s	4.0	5.0	4.50
961008-51s	3.5	5.0	4.25
961008-60s	6.0	5.0	5.50
961008-67s	4.0	5.0	4.50
961008-90s	4.0	5.0	4.50
961008-96s	3.0	5.0	4.00
Beta G6040	Resistant Check	4.5	5.0
961008-11s	4.0	5.5	4.75
961008-19s	4.0	5.5	4.75
961008-4s	4.0	5.5	4.75
961008-91s	3.0	5.5	4.25
961008-32s	4.0	5.5	4.75
961008-113s	5.0	5.5	5.25
961008-39s	2.5	5.5	4.00
961008-16s	5.0	5.5	5.25
961008-15s	3.5	5.5	4.50
961008-107s	4.5	6.0	5.25
961008-29s	4.0	6.0	5.00
961008-58s	5.0	6.0	5.50
961008-79s	5.5	6.0	5.75
961008-1s	4.5	6.0	5.25
961008-6s	4.5	6.0	5.25
961008-94s	4.0	6.0	5.00
961008-3s	5.5	6.0	5.75
961008-2s	4.5	6.0	5.25
961008-78s	4.0	6.0	5.00
961008-37s	4.5	6.0	5.25
961008-36s	4.0	6.0	5.00
961008-83s	3.0	6.0	4.50
961008-61s	5.0	6.5	5.75
961008-70s	5.0	6.5	5.75
961008-40s	4.0	6.5	5.25
961008-73s	5.0	6.5	5.75
961008-115s	4.5	6.5	5.50
961008-99s	4.5	6.5	5.50
961008-45s	5.0	6.5	5.75
961008-77s	5.0	6.5	5.75
961008-18s	5.0	6.5	5.75
961008-28s	4.5	6.5	5.50
961008-34s	5.0	6.5	5.75
961008-97s	4.0	6.5	5.25
94A092	4918 from Salinas	4.5	6.5

**Table 1. 1996 Curly Top Nursery - Kimberly, ID. Selfed families from the F<sub>2</sub> populations of the crosses 2890 (sp) x FC708 and 2859 m (sp) x FC708. Those lines performing as well or better than the resistant check variety are being increased.**

Designation	Disease Index <sup>1</sup>		Mean
	08/26/96	09/16/96	
LSD <sup>3</sup>	1.5	1.1	
961008-33s	4.0	6.5	5.25
961008-80s	5.5	6.5	6.00
961008-46s	5.0	6.5	5.75
961008-98s	5.0	6.5	5.75
961008-56s	5.0	6.5	5.75
961008-55s	3.5	6.5	5.00
961008-59s	5.5	6.5	6.00
961008-87s	5.5	7.0	6.25
961008-84s	5.5	7.0	6.25
961008-85s	5.5	7.0	6.25
961008-88s	5.5	7.0	6.25
961008-74s	5.0	7.0	6.00
961008-71s	5.5	7.0	6.25
961008-26s	4.5	7.0	5.75
961008-31s	5.0	7.0	6.00
961008-35s	5.5	7.0	6.25
961008-81s	5.5	7.0	6.25
961008-42s	5.0	7.0	6.00
961008-49s	5.5	7.0	6.25
961008-44s	6.0	7.0	6.50
961008-20s	4.5	7.0	5.75
961008-102s	5.5	7.0	6.25
961008-8s	5.0	7.0	6.00
961008-111s	3.0	7.0	5.00
961008-10s	5.5	7.5	6.50
961008-62s	5.0	7.5	6.25
961008-7s	5.5	7.5	6.50
961008-54s	5.5	7.5	6.50
961008-53s	6.0	7.5	6.75
961008-69s	6.5	7.5	7.00
961008-23s	6.5	7.5	7.00
961008-82s	6.0	7.5	6.75
961008-17s	6.0	7.5	6.75
961008-63s	5.5	7.5	6.50
961008-57s	6.0	7.5	6.75
961008-21s	6.0	8.0	7.00
961008-93s	6.5	8.0	7.25
961008-43s	6.5	8.0	7.25
961008-86s	6.0	8.0	7.00
961008-50s	6.0	8.0	7.00
961008-75s	6.5	8.0	7.25

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 9 (=dead).

<sup>2</sup> $\alpha = 0.05$ .

## **Germplasm Development for Resistance to Rhizoctonia Root Rot and Other Sugarbeet Diseases**

L. Panella, E. G. Ruppel, and R. J. Hecker (retired).

Root rot and leaf spot are two serious diseases of sugarbeets caused by fungi (*Rhizoctonia solani* and *Cercospora beticola*, respectively). The diseases caused by these fungi may produce a severe reduction of yield in many sugarbeet production areas. Cultural control measures are not adequate by themselves, and often no chemicals are registered for control of these diseases, or chemical control is expensive or environmentally unsafe. Increased levels of genetic resistance in sugarbeet varieties are needed to minimize growers' losses from these diseases.

Genetic information developed previously in our research was used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our cyclic improvement program. Germplasms in various stages of improvement were evaluated for resistance in inoculated field tests. Results of these tests were the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, register, etc. Germplasms likely to be useful for variety improvement were identified and released for use by other sugarbeet breeders.

Lines FC721 and FC721CMS were released in 1995. The lines were developed in our research project that has been contributed to, in kind, by the Beet Sugar Development Foundation. The newly released lines combine excellent root rot resistance with a moderate level of curly top and leaf spot resistance. Germplasms developed under the breeding program of Dr. R. J. Hecker are still being evaluated in the field. Nine of these germplasms and other germplasms from the Fort Collins program were field-tested in 1996 for resistance to *C. beticola*, *R. solani*, and the curly top virus (Tables 2-4).

At least three lines showing outstanding performance in 1996 field trials will be released in 1997. Additional lines selected for increased resistance to *Rhizoctonia* root rot in 1996 will be tested in 1997, and the most promising of these will be released in the future.

**Table 2. Experiment 3A, 1996 - Leaf Spot Evaluation of Fort Collins breeding lines.**

Seed source	Variety or description		Disease Index <sup>1</sup>		
			08/27/96	09/03/96	09/10/96
		LSD <sup>2</sup>	ns	ns	ns
892016H2		(from Fargo) FC607/Beta 2007 (2X)	2.33	3.00	3.17
941006	FC712(4X)	FC 712 colchicine doubled	2.50	2.50	3.33
Iso 66	R410	CR-RZM R210-# (C) (from Salinas)	2.83	3.00	3.33
831085HO	FC708	released	2.83	3.17	3.50
951016HO	FC723	EL44/FC708, mm	2.67	3.33	3.50
79A067	FC607	released	3.00	3.50	3.67
921019	FC729	FC712/A4, 3 cycles Rhizoc, MM	2.67	3.17	3.67
821051H2		<b>Leaf Spot Resistant Check</b>	3.00	3.50	3.67
911026HO	FC715	released	3.17	3.50	3.83
911031	FC717	released	2.83	3.50	3.83
Iso 4	R108	RZM R008 (from Salinas)	2.50	3.17	3.83
951016HO1	FC723CMS	EL44CMS/FC708, CMS	3.17	3.67	4.00
Iso 56	R526	RZM 426R (from Salinas)	3.17	3.50	4.00
Iso 3	R107	RZM R007 (from Salinas)	2.67	3.50	4.00
921024	FC709-2	+ 2 cycles Rhizoc & 1 cycle sucrose	3.00	3.33	4.00
921022	FC702-7	+ 7 cycles Rhizoc	2.83	3.33	4.17
941005	FC710(4X)	FC710 colchicine doubled	2.83	3.50	4.17
921021	FC703-5	+ 5 cycles Rhizoc	2.50	3.33	4.17
951017	FC727	FC703/(AJ-ZZ & Aula Dei & 67-436), MM	2.83	3.67	4.17
931002		<b>Leaf Spot Susceptible check</b>	3.50	3.67	4.17
931005HO1	FC721CMS	C718CMS//Syn (FC701/LSR-CTR), CMS	2.67	3.50	4.17
Iso 2	R106	RZM R006 Rovigo Line (from Salinas)	2.67	3.33	4.33
Iso 4	R436R2	RZM R336 (from Salinas)	3.33	3.67	4.33
Iso 1	R105	RZM R005 Rovigo Line (from Salinas)	3.00	3.67	4.33
892010H2		(from Fargo) FC607/H8277	3.50	4.00	4.50
931007	FC720	C718/(C718/FC708), mm	3.17	4.00	4.67
96A001	FC609	released	3.17	3.83	4.67
892008H2	FC907, BC4	(Fargo)	2.83	4.17	4.83
921025	FC728	(A4 & D2 & 309)/FC708, MM	3.33	4.17	5.00
931005HO	FC721	Syn (FC701/LSR-CTR)//C718, mm	3.67	4.17	5.00
Sp 1	R522	RZM-%S R322R4,...(C51) (from Salinas)	3.67	4.50	6.00
<b>TEST MEAN</b>			<b>2.96</b>	<b>3.54</b>	<b>4.13</b>

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 10 (=dead).

<sup>2</sup>ns = not significant at the  $\alpha=0.05$  level.

**Table 3. 1996 Rhizoctonia Nursery (4R) at Fort Collins, CO.**

Seed Source	Designation	Description	DI <sup>1</sup>	% Hlthy <sup>2</sup>	% Hvst <sup>3</sup>	Z% <sup>4</sup>	Hlthy	Z% Hvst
			LSD <sup>5</sup>	0.48		17.6		9.7
921024	FC709-2	+ 2 cycles Rhizoc & 1 cycle sucrose	0.85	100.0	100.0	90.0	90.0	90.0
921021	FC703-5	+ 5 cycles Rhizoc	0.91	96.0	100.0	82.6	90.0	90.0
921008	FC725	C37/FC707-2, MM	0.92	94.8	100.0	80.0	90.0	90.0
921022	FC702-7	+ 7 cycles Rhizoc	0.92	95.7	100.0	82.5	90.0	90.0
941038		FC701/LSR-CTR) O-type, mm	0.99	93.9	100.0	78.9	90.0	90.0
921025	FC728	(A4 & D2 & 309)/FC708, MM	1.00	88.6	100.0	72.6	90.0	90.0
931010	FC726	FC703-5/Peramono, MM	1.03	90.8	100.0	77.1	90.0	90.0
951017	FC727	FC703/(AJ-ZZ & Aula Dei & 67-436), MM	1.06	88.7	100.0	72.7	90.0	90.0
941005	FC710(4X)	FC710 colchicine doubled	1.06	95.7	100.0	84.5	90.0	90.0
941006	FC712(4X)	FC 712 colchicine doubled	1.07	92.6	100.0	78.1	90.0	90.0
831085HO	FC708	released	1.09	90.6	100.0	76.5	90.0	90.0
921019	FC729	FC712/A4, 3 cycles Rhizoc, MM	1.13	89.6	98.6	71.6	86.9	86.9
911028	FC716	released	1.18	88.5	98.7	72.2	87.0	87.0
911032	FC718	released	1.27	80.0	98.3	66.8	86.6	86.6
931005HO	FC721	Syn (FC701/LSR-CTR)//C718, mm	1.33	74.0	100.0	62.9	90.0	90.0
911037	FC719	released	1.36	82.6	95.7	68.1	84.5	84.5
751080H	FC703	Resistant Check	1.37	72.9	100.0	58.7	90.0	90.0
911031	FC717	released	1.38	81.3	95.3	67.1	82.2	82.2
831083	FC705/1	Highly Resistant Check	1.46	62.1	100.0	52.9	90.0	90.0
911026HO	FC715	released	1.47	68.6	94.7	56.8	81.5	81.5
931005HO1	FC721CMS	C718CMS//Syn (FC701/LSR-CTR), CMS	1.57	68.7	96.2	56.2	82.9	82.9
951035	FC714	Synthetic from (701/mm O-Type)aa//mm O-Type LSR-CTR	1.88	56.0	96.7	48.7	85.2	85.2
931017		Susceptible Check - (FC901/C817)//413	2.98	30.0	70.0	32.8	57.2	57.2

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 7 (= plant dead).

<sup>2</sup>Percent of healthy roots (disease classes 0 and 1 combined).

<sup>3</sup>Percent of harvestable roots (disease classes 0 through 3 combined).

<sup>4</sup>Percentages were transformed to arcsin-square roots to normalize the data for analyzes.

<sup>5</sup> $\alpha=0.05$ .

**Table 4. 1996 Curly Top Nursery - Kimberly, ID.**

Source	Designation	Pedigree	Mean DI <sup>1</sup>		
			1st <sup>2</sup>	2nd	Mean
			LSD <sup>3</sup>	1.5	1.1
911043HO	FC403	released	3.5	4.5	4.00
881036HO	FC606	released	3.8	4.5	4.13
<b>96A008</b>	<b>Beta G6040</b>	<b>Resistant Check</b>	4.3	4.8	4.50
921002HO	FC604	released	3.8	5.0	4.38
941029HO	FC401	released	4.0	5.0	4.50
86A048	FC607(4X)	released	4.0	5.0	4.50
771059HO	FC605	released	4.3	5.3	4.75
731028HO	FC902	released	5.0	5.5	5.25
94A092	4918	from Salinas	4.8	5.8	5.25
811003HO	FC607	released	4.5	5.8	5.13
911042HO	FC402	released	4.5	5.8	5.13
86A046	FC606(4X)	released	4.8	6.0	5.38
911031	FC717	released	5.5	6.3	5.88
921025	FC728	released	4.8	6.3	5.50
931010	FC726	released	4.8	6.3	5.50
931005HO	FC721	Syn (FC701/LSR-CTR)//C718, mm	5.0	6.3	5.63
941006	FC712(4X)	FC 712 colchicine doubled	5.8	6.5	6.13
661208HO	FC502-2	released	5.3	6.5	5.88
911032	FC718	released	5.8	6.5	6.13
921019	FC729	FC712/A4, 3 cycles Rhizoc, MM	5.5	6.5	6.00
921008	FC725	released	5.8	6.5	6.13
911026HO	FC715	released	5.0	6.8	5.88
951017	FC727	FC703/(AJ-ZZ & Aula Dei & 67-436), MM	5.3	6.8	6.00
871032HO	FC506	released	5.5	6.8	6.13
911037	FC719	released	5.8	6.8	6.25
921024	FC709-2	+ 2 cycles Rhizoc & 1 cycle sucrose	6.5	6.8	6.63
831085HO	FC708	released	6.0	6.8	6.38
921021	FC716	released	5.5	6.8	6.13
941002	L603	French Rhizomania line	5.3	7.0	6.13
771067HO	FC504	released	7.3	7.5	7.38

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 9 (=dead).

<sup>2</sup>Evaluations were made on August 26<sup>th</sup> and September 16<sup>th</sup>.

<sup>3</sup> $\alpha=0.05$ .



**Genetic Relationships among Isolates of *Rhizoctonia Solani*  
and Variation in Pathogenicity to Sugarbeet**

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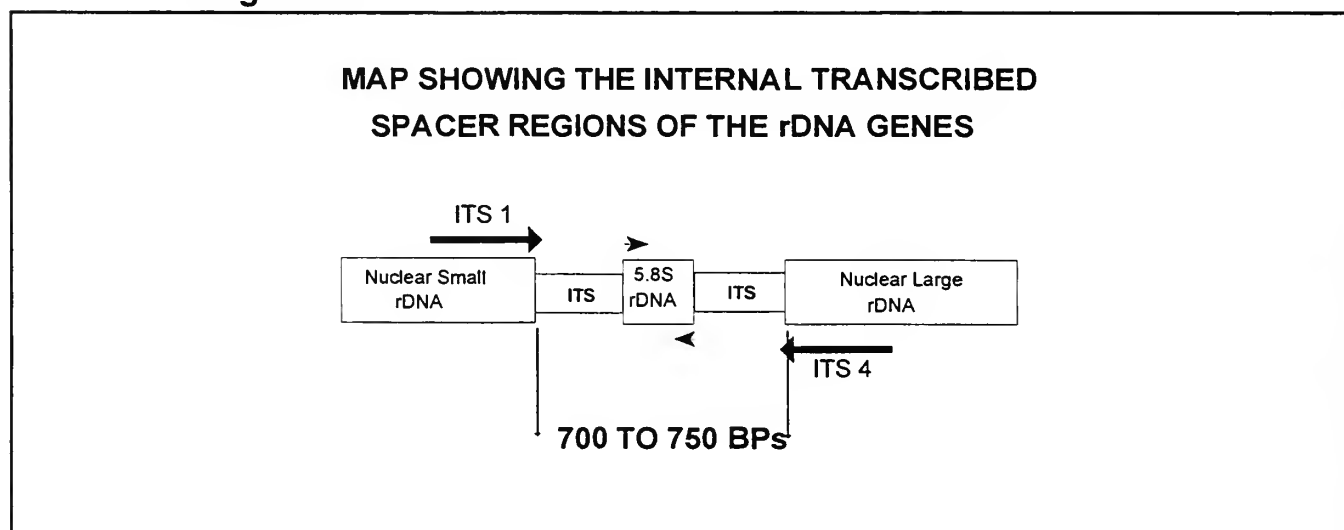
USDA Agricultural Research Service <sup>1</sup> Sugarbeet Research Unit, Fort Collins, CO and <sup>2</sup>Plant Genetic Resources Conservation Unit, Griffin, GA.

Currently, it is possible to assay the pathogenicity to sugarbeet of an isolate of *Rhizoctonia solani* through a greenhouse bioassay only, which may take 12 to 16 weeks. Although there has been recent work done on the phylogenetics of this pathogen, evolutionary relationships among isolates have not been well correlated with the host specificity of the fungus. Whether the pathogenicity to sugarbeet has evolved once or more than once in this fungus could substantially influence its interaction(s) with the sugarbeet plant.

*R. solani* is divided into anastomosis groups (AGs) based on the ability of the hyphae to fuse and exchange genetic material and into subgroups based on morphological, physiological, or, more recently, biochemical and molecular markers. The internal transcribed spacer (ITS) sequences flanking the 5.8S ribosomal RNA gene (rDNA) (Figure 2) have been used for this purpose and, in general, for phylogenetic studies because they are extremely variable within species.

Isolates of *R. solani* from AG-4 cause seedling damping-off in sugarbeet, and isolates from AG-2 primarily cause root and crown rot in mature beets. AG-2 is divided into subgroups AG-2-1 and AG-2-2 based on frequency of anastomosis and thiamine auxotrophy (AG-2-2). AG-2-2, which is pathogenic to sugarbeets, is further divided into subgroups IIIB or IV based on growth at 35°C. In this country, we have found both AG-2-2 IIIB and AG-2-2 IV to be pathogenic on sugarbeet and group IIIB to be the most virulent.

**Figure 2.**



The polymerase Chain Reaction (PCR) was used to amplify the DNA of 92 isolates of *R. solani* coding for the 5.8S ribosomal RNA gene (rDNA) as well as the two flanking ITS regions. This was done with the ITS1 and ITS4 primers (Figure 2) (Lee & Taylor, 1990). Restriction enzymes that recognize

four base-pair sites (*AluI*, *HaeIII*, *HhaI*, *HinfI*, *HpaI*, *RsaI*) were used to create restriction fragment length polymorphisms (RFLPs) from the amplified DNA fragments. There were also, in some cases, initial differences in the size of the amplified length of DNA, which varied from approximately 700 to 750 base pairs. The DNA was separated on agarose gels, visualized with ethidium bromide, and photographed. The enlarged photographs were used to estimate the fragment sizes, by comparison with markers of known size (from a *HaeIII* digest of  $\Phi$ X174RF1). Each isolate was scored for the presence/absence of all possible RFLPs generated by each restriction enzyme (5 to 10 RFLPs each). These data were analyzed and a phylogenetic tree was generated from this information. This tree did discriminate between AG-2-2 isolates and other AGs but did not give adequate discrimination within AG-2-2 or among the other AGs.

Isozyme markers from four enzyme systems ( $\alpha$ - acid phosphatase [ $\alpha$ -ACP], phosphoglucosmutase (PGM), glucose-6-phosphate-dehydrogenase (G6PDH), and malate dehydrogenase (MDH)) are being used to further discriminate among isolates. This is ongoing research, and we anticipate it will be finished this year.

In collaboration with the USDA-ARS Plant Introduction Station at Griffin, GA, we have sequenced the DNA of the two ITS regions as well as the 5.8S rDNA gene from 70 isolates of *R. solani* (Table 5). This was done with a PCR reaction using the ITS-1 and ITS-4 primers, as well as primers on either side of the 5.8S rDNA gene (Figure 2). These sequence data, with the isozyme data, will allow us to characterize the genetic diversity among *Rhizoctonia* isolates. These data have been used to make a preliminary phylogenetic tree representing the genetic relationships among different isolates of *R. solani* (Figure 3). Once these data are fully analyzed, they also will provide the means to develop a quick molecular technique to identify those isolates which are pathogenic to sugarbeet.

We are also testing the *Rhizoctonia* isolates for their pathogenicity to sugarbeet. The *R. solani* isolates have been tested for their virulence to sugarbeet seedlings. The Chi-square values (difference between the untreated control and the reaction of two sugarbeet lines to each isolate) will be used to classify the isolates based on their pathogenicity. These isolates also were tested in the greenhouse for pathogenicity on 10-wk-old sugarbeet roots (one resistant and one susceptible line). The test was a randomized complete block design with six replicates. Results of the greenhouse screening will be correlated with the phylogenetic relationships determined from the sequence data to see if all the isolates pathogenic to sugarbeet belong in the same genetic grouping. We also will look for short, unique sequences within the ITS regions that can be used to “fingerprint” isolates of *R. solani* that are pathogenic on sugarbeet.

Lee, S.B., and J.W. Taylor. 1990. Isolation of DNA from fungal mycelia and single spores. Pages 282-287, in M.A. Innis, D.H. Gelfand, J.J. Sninsky and T.J. White (eds.), PCR Protocols: A Guide to Methods and Applications. Harcourt Brace Jovanovich, San Diego.

**Table 5.** The isolates of *Rhizoctonia solani* used in the genetic diversity study are listed with an identifying number; the code of the original donor; the source, AG designation, location where collected and any remarks from the donor; the donor's name.

Donor's										
Rhzc#	Code	Anastomosis Group	ISG	Source/location/remarks	Received from					
1	CS-2	AG-1 IA		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
2	Shiba2	AG-1 IB		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
3	BV-7	AG-1 IC		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
4	FC-2S	AG-2-1		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
5	C-116S	AG-2-2 IIIB	IIIB	AG Testers from Akira Ogoshi	Earl Ruppel, CO					
6	RI64S	AG-2-2 IV	IV	AG Testers from Akira Ogoshi	Earl Ruppel, CO					
7	ST11-6	AG-3		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
8	R101	AG-4 HG-I		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
9	ST6-1	AG-5		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
10	IS1-1	AG-6 HG-I		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
11	1556	AG-7		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
12	TS2-4S	AG-BI (Bridging Isolate)		AG Testers from Akira Ogoshi	Earl Ruppel, CO					
13	S-21	AG-9		AG tester from Carol Windels (originally from Neil Anderson) - originally from Don Carling, Palmer, AK	Earl Ruppel, CO					
14	72	AG-8		AG Tester from Steven Neate - Australia [R-72on slant]; from clover roots, Conalbyn, Australia]	Earl Ruppel, CO					
15	R-7	AG-4		SB foliage, Willcox, AZ; by EGR	Earl Ruppel, CO					
16	R-9	AG-2-2	IIIB	SB root, Colorado; orig. B-6 of Pierson & Gaskill	Earl Ruppel, CO					
17	48	AG-2-1		AG Testers from Carol Windels (originally from Neil Anderson) - Retested = AG-2-1	Earl Ruppel, CO					
18	H-3-77	AG-2-2	IV	AG Testers from Carol Windels (originally from Neil Anderson)	Earl Ruppel, CO					
19	P42	AG-3		AG Testers from Carol Windels (originally from Neil Anderson)	Earl Ruppel, CO					
20	S-284	AG-2-?	IIIB	AG Testers from R. T. Sherwood -- from NC Gypsophilla stem (said to be "better" than W-22)	Earl Ruppel, CO					
21	W-22	AG-2-2	IIIB	AG Testers from R. T. Sherwood -- from WI bean root (ATCC 18619)	Earl Ruppel, CO					
22	W-24	AG-3		AG Testers from R. T. Sherwood -- from WI potato stem (ATCC 14701)	Earl Ruppel, CO					
23	NBR-1	AG-2-2	IIIB	SB root, Imperial, NE, by EGR (AG-2-2)	Earl Ruppel, CO					
24	R-1	AG-2-2	IIIB	SB root, Platteville, CO; by T. Antonopoulos for Gaskill ("A")(AG-2-2)	Earl Ruppel, CO					
25	R-2	AG-2-2	IIIB	SB root, Platteville, CO; by T. Antonopoulos for Gaskill (AG-2-2)	Earl Ruppel, CO					
26	R-4	AG-2-2	IIIB	SB root, Brighton, CO; by EGR (AG-2-2)	Earl Ruppel, CO					
27	R-5	AG-4		SB crown, Ft. Morgan, CO; by EGR (AG-4)	Earl Ruppel, CO					
28	R-6	AG-4		SB foliage, Swink, CO; by EGR (AG-4)	Earl Ruppel, CO					
29	R-8	AG-2-2	IIIB	SB root, Willcox, AZ; by EGR (AG-2-2)	Earl Ruppel, CO					

**Table 5.** The isolates of *Rhizoctonia solani* used in the genetic diversity study are listed with an identifying number; the code of the original donor; the source, AG designation, location where collected and any remarks from the donor; the donor's name.

Donor's						
Rhzc#	Code	Anastomosis Group	ISG	Source/location/remarks	Received from	
30	R-14	AG-2-2 - LOST		SB root, Wellington, CO; by EGR (AG-2-2)	Earl Ruppel, CO	
31	R-239	AG-1		From Mike Davis (Berkeley, CA); readily forms teleomorph stage (AG-4 - Retested = AG-1)	Earl Ruppel, CO	
32	R-1411	AG-4		From Lysle Leach; highly virulent on seedlings	Earl Ruppel, CO	
33	R1	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
34	R3	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
35	R4	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
36	R6	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
37	R8	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
38	R17	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
39	R19	AG-2-2 - LOST		Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
40	R27	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
41	R33	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
42	R35	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
43	R36	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
44	R37	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
45	R86	AG-2-2	IIIB	Isolates collected in Texas - isolated from wheat	Charlie Rush, TX	
46	R98	AG-2-2	IIIB	Isolates collected in Texas - isolated from sugarbeet root	Charlie Rush, TX	
47	2C1	AG-2-2	IIIB	Montana	Bill Bugbee, ND	
48	5E13	AG-2-1		Hollandale, MN (Retested - probably AG-2-1)	Bill Bugbee, ND	
49	2A13	AG-2-2	IIIB	Montana	Bill Bugbee, ND	
50	1A9	AG-2-2	IV	(on bran-soil) California (via Dr. Carling)	Bill Bugbee, ND	
51	2C13	AG-2-2	IV	Montana	Bill Bugbee, ND	
52	7A1	AG-2-2	IV	Ferry-Morse Seed Co. MN	Bill Bugbee, ND	
53	5C5	AG-2-2	IV	MN (via Carol Windels)	Bill Bugbee, ND	
54	7A5	AG-2-2	IV	Ferry-Morse Seed Co. MN	Bill Bugbee, ND	
55	2E13	AG-2-2	IIIB	Montana	Bill Bugbee, ND	
56	2C5	AG-2-2	IV	Montana	Bill Bugbee, ND	
57	2E3	AG-2-2	IIIB	Montana	Bill Bugbee, ND	
58	7A9	AG-2-2	IV	Ferry-Morse Seed Co. MN	Bill Bugbee, ND	

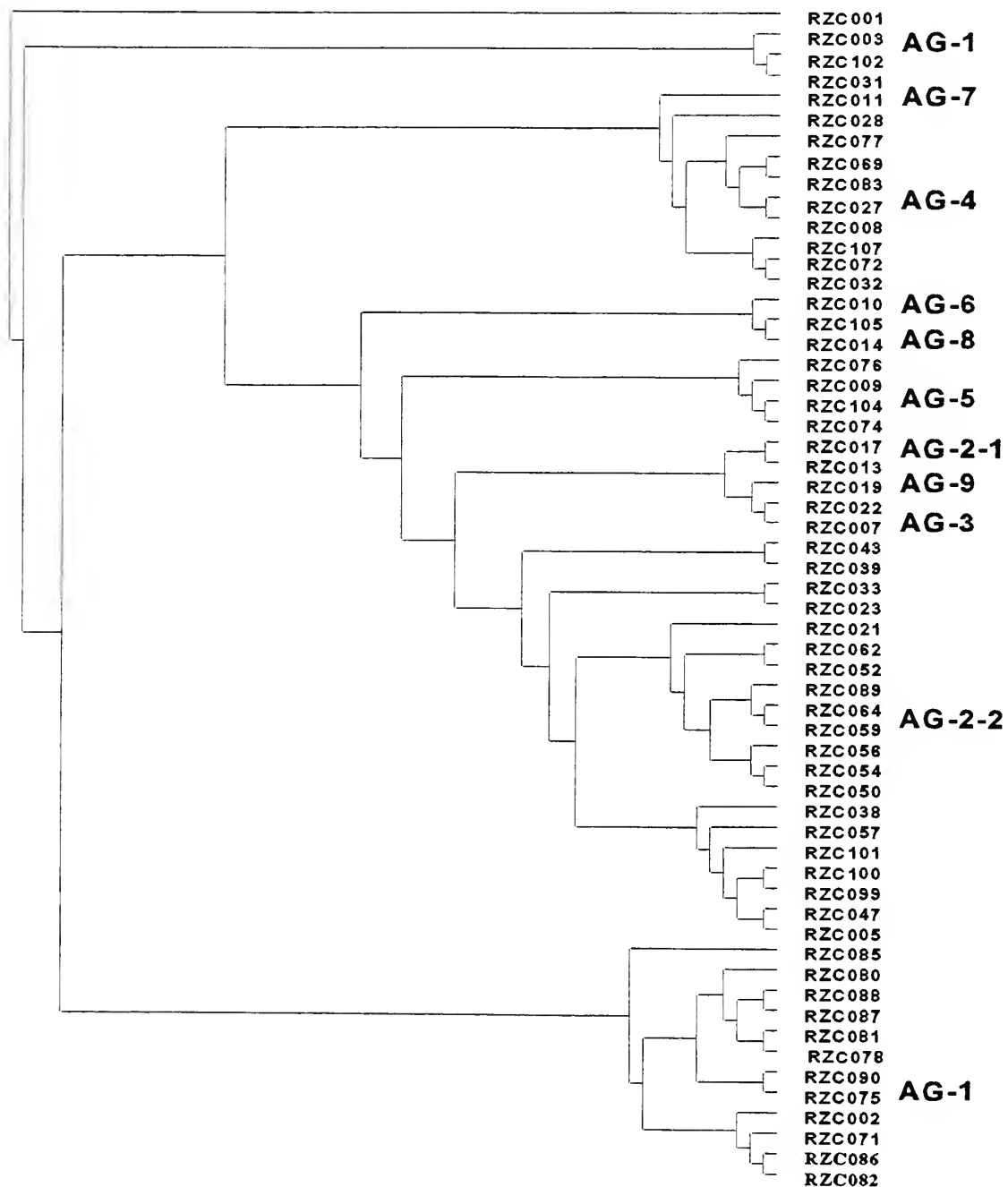
**Table 5.** The isolates of *Rhizoctonia solani* used in the genetic diversity study are listed with an identifying number; the code of the original donor; the source, AG designation, location where collected and any remarks from the donor; the donor's name.

Donor's					
Rhzc#	Code	Anastomosis Group	ISG	Source/location/remarks	Received from
59	H502	AG-2-2	IV		Leonard Herr ,OH
60	H509	AG-2-2	IV		Leonard Herr ,OH
61	H549	AG-2-2	IV		Leonard Herr ,OH
62	H556	AG-2-2	IV		Leonard Herr ,OH
63	H581	AG-2-2	IV		Leonard Herr ,OH
64	H582	AG-2-2	IV		Leonard Herr ,OH
65	H583	AG-2-2	?		Leonard Herr ,OH
66	H585	AG-2-2	?		Leonard Herr ,OH
67	H586	AG-2-2	IV		Leonard Herr ,OH
68	H589	AG-2-2	IV		Leonard Herr ,OH
69	RH51	AG-4		Obihiro, Hokkaido, 1973 Damping-off	Dr. H. Uchino, Japan
70	RH52	AG-4		Obihiro, Hokkaido, 1973 Damping-off	Dr. H. Uchino, Japan
71	RH72	AG-1		Obihiro, Hokkaido, 1974 Damping-off	Dr. H. Uchino, Japan
72	RH74	AG-4		Makubetsu, Hokkaido, 1974 Damping-off	Dr. H. Uchino, Japan
73	RH105	AG-1		Makubetsu, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
74	RH107	AG-5		Bihoro, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
75	RH108	AG-1		Furano, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
76	RH109	AG-5		Furano, Hokkaido, 1975 Damping-off	Dr. H. Uchino, Japan
77	RH141	AG-4		Obihiro, Hokkaido, 1976 Damping-off	Dr. H. Uchino, Japan
78	RH147	AG-1		Obihiro, Hokkaido, 1976 Damping-off (AG-1 - Retested = AG-1)	Dr. H. Uchino, Japan
79	RH152	AG-4		Obihiro, Hokkaido, 1977 Damping-off	Dr. H. Uchino, Japan
80	RH26	AG-1		Obihiro, Hokkaido, 1971 Leaf blight	Dr. H. Uchino, Japan
81	RH88	AG-1		Obihiro, Hokkaido, 1974 Leaf blight	Dr. H. Uchino, Japan
82	RH89	AG-1		Makubetsu, Hokkaido, 1974 Leaf blight	Dr. H. Uchino, Japan
83	RH91	AG-4		Obihiro, Hokkaido, 1974 Leaf blight	Dr. H. Uchino, Japan
84	RH126	AG-1		Obihiro, Hokkaido, 1975 Leaf blight	Dr. H. Uchino, Japan
85	RH137	AG-1		Obihiro, Hokkaido, 1976 Leaf blight	Dr. H. Uchino, Japan
86	RH158	AG-1		Obihiro, Hokkaido, 1977 Leaf blight	Dr. H. Uchino, Japan
87	RH159	AG-1		Obihiro, Hokkaido, 1977 Leaf blight	Dr. H. Uchino, Japan

**Table 5.** The isolates of *Rhizoctonia solani* used in the genetic diversity study are listed with an identifying number; the code of the original donor; the source, AG designation, location where collected and any remarks from the donor; the donor's name.

Donor's			Source/location/remarks		Received from
Rhzc#	Code	Anastomosis Group	ISG		
88	RH160	AG-1		Makubetsu, Hokkaido, 1977 Leaf blight	Dr. H. Uchino, Japan
89	RH193	AG-2-2	IV	Obihiro, Hokkaido, 1990 Leaf blight	Dr. H. Uchino, Japan
90	RH198	AG-1		Obihiro, Hokkaido, 1991 Leaf blight (AG-2-2 - Retested = AG-1)	Dr. H. Uchino, Japan
91	RH65	AG-2-2	IV	Obihiro, Hokkaido, 1973 Root rot	Dr. H. Uchino, Japan
92	RH180	AG-2-2	IV	Bihoro, Hokkaido, 1984 Root rot	Dr. H. Uchino, Japan
93	RH184	AG-2-2	IV	Fukagawa, Hokkaido, 1986 Root rot	Dr. H. Uchino, Japan
94	RH188	AG-2-2	IV	Otoe, Hokkaido, 1986 Root rot	Dr. H. Uchino, Japan
95	RH189		IV	Obihiro, Hokkaido, 1989 Root rot	Dr. H. Uchino, Japan
96	RH195	AG-2-2	IV	Kamifurano, Hokkaido, 1991 Root rot	Dr. H. Uchino, Japan
97	RH196	AG-2-2	IV	Furano, Hokkaido, 1991 Root rot	Dr. H. Uchino, Japan
98	87-36-1	AG-2-2	IIIB	AG-2-2 from Pinto Bean; Trenton, ND	Dr. Carol Windels
99	87-36-2	AG-2-2	IIIB	AG-2-2 from Pinto Bean; Trenton, ND	Dr. Carol Windels
100	87-36-3	AG-2-2	IIIB	AG-2-2 from Pinto Bean; Trenton, ND	Dr. Carol Windels
101	87-36-4	AG-2-2	IIIB	AG-2-2 from Pinto Bean; Trenton, ND	Dr. Carol Windels
102	43	AG-1		AG Testers from Carol Windels (originally from Neil Anderson)	Earl Ruppel, CO
103	140	AG-4		AG Testers from Carol Windels (originally from Neil Anderson)	Earl Ruppel, CO
104	441	AG-5		AG Testers from Carol Windels (originally from Neil Anderson)	Earl Ruppel, CO
105	182	AG-8		AG Tester from Steven Neate - Australia -- (R-182 on slant); from soil debris	Earl Ruppel, CO
106	S-220	AG-1		AG Testers from R. T. Sherwood -- from Lotus leaves; North Carolina	Earl Ruppel, CO
107	S-289	AG-4		AG Testers from R. T. Sherwood -- from NC cotton hypocotyl	Earl Ruppel, CO

**Figure 3. Preliminary phylogenetic tree showing relationships among isolates of *Rhizoctonia solani* based on DNA sequence of the ITS regions.**



**EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO  
*RHIZOCTONIA SOLANI*, A CAUSAL FUNGUS OF SUGARBEET ROOT ROT  
(BSDF Project 903)**

**1996 Evaluations of Contributor Lines for Reaction to *Rhizoctonia solani*.**

E. G. Ruppel & L. Panella

Randomized, complete-block designs with five replicates were used to evaluate Fort Collins ARS breeding germplasm. *Rhizoctonia*-resistant line FC703 and highly susceptible FC901/C817//413 were included as internal controls, along with highly resistant FC705-1. One-row plots, planted in mid-May, were 4.3 m (14 feet) long with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. Inoculation with dry, ground, barley-grain inoculum of *Rhizoctonia solani* isolate R-9 was performed on July 31; immediately after inoculation, a cultivation was performed so as to throw soil into the beet crowns. Inoculum was moistened and carried into the crowns by overhead sprinkler irrigation, which was applied immediately after inoculation and then intermittently for the next four days. Succeeding irrigations were done by furrow. Before field inoculation, we tested inoculum for virulence on 2-mo-old sugarbeets in the greenhouse; our 1996 inoculum was highly virulent, rotting all inoculated plants. The experimental design, methods, results, and statistical analyses were provided to the appropriate company breeders or representatives.

Although planting was on schedule, a severe hail storm that caused significant plant damage necessitated a 2-week delay in inoculations. Following inoculation, frequent early rains and a relatively cool summer (Figure 1) led to a milder root rot epidemic than normal in our nursery. Nevertheless, differences among entries in all tests were highly significant ( $P < 0.0001$ ). Mean DIs across all tests for highly resistant FC705-1, resistant FC703, and the highly susceptible check were 1.3, 1.3, and 2.9, respectively. Percentages of healthy roots were 76, 75, and 33 for these controls. Percentages of roots in disease classes 0 thru 3 were 97, 94, and 70, respectively. The highest and lowest DIs for contributor lines were 5.7 and 1.1, respectively.



**CERCOSPORA LEAF SPOT RESEARCH AND BREEDING FOR  
CERCOSPORA/CURLY TOP RESISTANCE  
(BSDF Project 441)**

**1996 Field Research on Cercospora Leaf Spot of Sugarbeet.**

L. Panella, E. G. Ruppel, and G.A Smith.  
USDA-ARS Fort Collins, CO and Fargo, ND

We, at Fort Collins, are pleased to participate and lead this cooperative research project between the ARS and the BSDF. The project primarily involved field studies conducted on 35 acres of leased land near Windsor, CO. Previously, at our CSU South Farm location, the only cost to ARS was the cost of irrigation water, however, CSU needed the South Farm land for construction purposes, and we were asked to vacate the field plots there. In preparation for the 1996 field season, the land at the Windsor Farm was planted to barley in 1995. Our 1996 field experiments were planted in an area that had been in barley for 1 year, previously having been the site of Dr. Ed Schweizer's weed research program.

Randomized complete-block designs with three replications were used to evaluate breeding germplasm. Two-row plots were 4 m (12 feet) long, with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. After a dubious start due to the weather, I am happy to say that our epidemic developed nicely and we obtained excellent results in most experiments. Our first inoculation, which we initially planned for June 21, was delayed until June 29 because of rain and a wet field. We began the inoculation procedure on June 28, but a downpour of rain halted our efforts. Fortunately, hot, dry conditions after the rain (Figure 1) permitted the inoculation to be completed on the 29th. The second inoculation was to be done on July 3, but a severe hail storm shattered leaves so badly that we postponed it until July 11 to allow the plants to recover somewhat. Despite our weather problems, the epidemic progressed favorably due to the warm days and nights, and we rated lines on August 27 and September 3 and 10.

The peak of the epidemic occurred close to the last rating date. On that date, means of the resistant and susceptible internal controls were 4.4 and 6.1 (scale of 0-10), respectively, across the nursery. In 1995 (September 14), these means were 3.9 and 5.9, respectively. Means of lines on September 10 ranged from 2.0-7.8, compared with 3.8-7.2 in 1995. Unfortunately there was extreme variation within experiment 4A (Table 3), which contained some of the Fort Collins breeding lines, and differences among lines were not significant. However, there were significant differences among entries in experiment 8A (Table 6), which contained selfed-family progeny rows planted in one-row, 4-meter (12-foot) plots in two replications.

## **Cercospora-Resistant Populations for Multiple Disease Resistance in Sugarbeet**

Lee Panella

Increased resistance to *Cercospora* continues to be an extremely important goal. If the level of resistance available in most *Cercospora*-resistant experimental lines were present in commercial hybrids (along with good sugar and seed yield), the need for fungicides would be greatly reduced. That continued improvement in genetic resistance to this serious pathogen is still needed is evident by the occurrence of *Cercospora* strains that are resistant to our most potent fungicides. Additionally, some fungicides may be removed from the market because of their perceived or real threat to the environment. In many areas where *Cercospora* leaf spot is a problem, the curly top virus also causes significant losses. Additionally, there are some growing areas in which combined resistance to *Cercospora* leaf spot, rhizomania, curly top, and *Rhizoctonia* root rot are desirable. Germplasm is needed with combined resistance to these diseases, along with good combining ability for yield components.

Two populations have been created to produce a germplasm pool from which to select multigerm, O-type, and CMS germplasm with resistance to *Cercospora* leaf spot, curly top, rhizomania, and other diseases. The first population is a monogerm population ([2890aa & 2589aa x FC607& FC604] and the reciprocal) segregating for *Cercospora* leaf spot, rhizomania, other disease resistances, self-fertility, and genetic male sterility. The parents are from the USDA-ARS Salinas and Fort Collins programs. It should provide a source of monogerm, O-type lines.

Selfed progeny ( $S_1$ ) rows of this monogerm population ( [2890 & 2589aa ] / [FC607 & FC604] and the reciprocal), segregating for *Cercospora* leaf spot, rhizomania, and other disease resistances, self-fertility, and genetic male sterility, were grown in the 1996 Fort Collins leaf spot nursery. The best performing lines in this nursery were selected (Table 6). Many of these lines also were tested in the BSDF curly top nursery in Kimberly Idaho (Table 7), and the top performers from this nursery that also showed good leaf spot resistance were selected.

Mother roots from these best performing families were harvested from the leaf spot nursery in Fort Collins and are being crossed in the greenhouse this winter. This seed will be tested for leaf spot, curly top, and rhizomania resistance next summer.

A multigerm source population, originating from the cross (4918aa/R278/FC902), is segregating for *Cercospora* leaf spot, rhizomania resistance, other disease resistances, and self-fertility. The combination of Salinas and Fort Collins germplasm should provide a source of multigerm pollinators with combined leaf spot, curly top, and rhizomania resistance. This population ( $F_2$  plants) was grown in the 1996 steckling nursery at Fort Collins and increased in bulk.

This multigerm population will be crossed to *Cercospora*-resistant selections from the multigerm populations derived from FC907 x FC709-2 and the polycross with FC607 and used to produce germplasm with resistance to *Cercospora*, rhizomania, and curly top, from which multigerm pollinators can be selected.

**Table 6. Experiment 8A, 1996 Leaf spot Nursery Fort Collins, CO. Selfed families from the F<sub>2</sub> populations of the crosses 2890 (sp) & 2859 m (sp) x FC07 & FC604. The top 10% performing families are being increased.**

Entry no.	Seed no.	Mean @ Date <sup>1</sup>		
		1	2	3
Resistant Check	821051H2	2.25	2.50	3.00
1552	961007-2s	2.75	3.00	3.00
1564	961007-15s	2.25	3.00	3.25
1605	961007-74s	2.75	3.75	3.25
1566	961007-19s	2.75	3.50	3.50
1558	961007-8s	3.00	3.00	3.50
1600	961007-67s	2.75	3.25	3.50
1578	961007-35s	2.75	3.00	3.75
1575	961007-31s	2.50	3.75	3.75
1553	961007-3s	2.50	3.75	3.75
1598	961007-63s	2.75	3.25	3.75
1599	961007-65s	2.00	3.25	3.75
1587	961007-51s	2.50	3.25	3.75
1618	961007-89s	2.50	3.25	3.75
1554	961007-4s	2.50	3.00	4.00
1570	961007-26s	2.00	3.25	4.00
1579	961007-36s	3.25	3.50	4.00
1569	961007-25s	2.50	3.25	4.00
1590	961007-54s	2.50	3.25	4.00
1592	961007-57s	3.00	3.50	4.00
1560	961007-11s	2.75	3.75	4.00
1597	961007-62s	2.50	3.50	4.00
1594	961007-59s	2.75	3.75	4.25
1584	961007-46s	2.00	3.50	4.25
1556	961007-6s	3.00	3.50	4.25
1615	961007-86s	2.50	3.50	4.25
1612	961007-83s	3.00	3.75	4.25
1586	961007-49s	2.75	3.50	4.25
1562	961007-13s	2.50	3.75	4.25
1563	961007-14s	3.50	4.25	4.50
1588	961007-52s	2.75	4.25	4.50
1561	961007-12s	2.50	4.00	4.50
1568	961007-23s	2.75	3.50	4.50
1585	961007-47s	2.50	3.50	4.50
1609	961007-80s	2.50	3.75	4.50
1603	961007-70s	2.25	3.00	4.50
1596	961007-61s	2.50	3.50	4.50
1621	961007-96s	3.00	3.50	4.50
1593	961007-58s	3.25	3.75	4.50
1617	961007-88s	2.50	3.75	4.50

**Table 6. Experiment 8A, 1996 Leaf spot Nursery Fort Collins, CO. Selfed families from the F<sub>2</sub> populations of the crosses 2890 (sp) & 2859 m (sp) x FC07 & FC604. The top 10% performing families are being increased.**

Entry no.	Seed no.	Mean @ Date <sup>1</sup>		
		1	2	3
Resistant Check	821051H2	2.25	2.50	3.00
1552	961007-2s	2.75	3.00	3.00
1564	961007-15s	2.25	3.00	3.25
1605	961007-74s	2.75	3.75	3.25
1566	961007-19s	2.75	3.50	3.50
1558	961007-8s	3.00	3.00	3.50
1600	961007-67s	2.75	3.25	3.50
1578	961007-35s	2.75	3.00	3.75
1575	961007-31s	2.50	3.75	3.75
1553	961007-3s	2.50	3.75	3.75
1598	961007-63s	2.75	3.25	3.75
1599	961007-65s	2.00	3.25	3.75
1587	961007-51s	2.50	3.25	3.75
1618	961007-89s	2.50	3.25	3.75
1554	961007-4s	2.50	3.00	4.00
1570	961007-26s	2.00	3.25	4.00
1579	961007-36s	3.25	3.50	4.00
1569	961007-25s	2.50	3.25	4.00
1590	961007-54s	2.50	3.25	4.00
1592	961007-57s	3.00	3.50	4.00
1560	961007-11s	2.75	3.75	4.00
1597	961007-62s	2.50	3.50	4.00
1594	961007-59s	2.75	3.75	4.25
1584	961007-46s	2.00	3.50	4.25
1556	961007-6s	3.00	3.50	4.25
1615	961007-86s	2.50	3.50	4.25
1612	961007-83s	3.00	3.75	4.25
1586	961007-49s	2.75	3.50	4.25
1562	961007-13s	2.50	3.75	4.25
1563	961007-14s	3.50	4.25	4.50
1588	961007-52s	2.75	4.25	4.50
1561	961007-12s	2.50	4.00	4.50
1568	961007-23s	2.75	3.50	4.50
1585	961007-47s	2.50	3.50	4.50
1609	961007-80s	2.50	3.75	4.50
1603	961007-70s	2.25	3.00	4.50
1596	961007-61s	2.50	3.50	4.50
1621	961007-96s	3.00	3.50	4.50
1593	961007-58s	3.25	3.75	4.50
1617	961007-88s	2.50	3.75	4.50

**Table 7. 1996 Curly Top Nursery - Kimberly, ID. Selfed families from the F<sub>2</sub> populations of the crosses 2890 (sp) & 2859 m (sp) x FC07 & FC604. Those lines performing as well or better than the resistant check variety are being increased.**

Designation		Disease Index <sup>1</sup>		Mean
		08/26/96	09/16/96	
LSD <sup>2</sup>		1.5	1.1	
961007-92s		2.5	4.0	3.25
961007-94s		4.0	4.5	4.25
961007-72s		2.5	4.5	3.50
961007-1s		3.0	4.5	3.75
961007-88s		3.5	4.5	4.00
96A008	Beta G6040	4.5	5.0	4.75
961007-6s		4.0	5.0	4.50
961007-20s		3.5	5.0	4.25
961007-9s		4.0	5.5	4.75
961007-100s		3.5	5.5	4.50
961007-33s		3.5	5.5	4.50
961007-26s		5.0	5.5	5.25
961007-58s		5.5	6.0	5.75
961007-8s		5.0	6.0	5.50
961007-22s		4.5	6.0	5.25
961007-69s		4.5	6.0	5.25
961007-28s		4.0	6.0	5.00
961007-80s		5.0	6.0	5.50
961007-78s		5.5	6.0	5.75
961007-52s		5.0	6.0	5.50
961007-86s		4.5	6.0	5.25
961007-16s		4.0	6.0	5.00
961007-42s		4.5	6.5	5.50
94A092	4918	4.5	6.5	5.50
961007-47s		5.0	6.5	5.75
961007-73s		4.5	6.5	5.50
961007-3s		5.0	6.5	5.75
961007-99s		4.5	6.5	5.50
961007-18s		5.5	7.0	6.25
961007-24s		4.5	7.0	5.75
961007-21s		6.0	7.0	6.50
961007-13s		5.5	7.0	6.25
961007-14s		5.5	7.0	6.25
941002	L603	5.0	8.0	6.50

<sup>1</sup>Disease Index is based on a scale of 0 (=healthy) to 9 (=dead).

<sup>2</sup> $\alpha = 0.05$ .

## **Multigerm Pollinators Population with *Cercospora* Leaf Spot Resistance and Agronomic Quality**

L. Panella<sup>1</sup> & G. A. Smith<sup>2</sup>

<sup>1</sup>Geneticist, USDA-ARS Crops Research Laboratory , Fort Collins, CO

<sup>2</sup>Geneticist & Research Leader, USDA-ARS Northern Crop Science Lab, Fargo, ND

Our objective of this program is the development, for release to the sugarbeet seed industry, of sugarbeet multigerm germplasm with strong resistance to *Cercospora* leaf spot and superior agronomic quality.

A population from which to choose multigerm pollinators highly resistant to *Cercospora*, with good combining ability for agronomic traits, is being developed. A cross among a highly *Cercospora*-resistant line (FC607 - ♀), a smooth root line from the USDA-ARS sugarbeet research group in East Lansing (SR87 - ♂), and commercial diploid hybrids developed by the defunct Great Western program (MonoHy A4, MonoHy T6, and MonoHy T7 - ♂'s) forms the basis of this population. F<sub>2</sub> seed from this multigerm population was harvested this fall and will be planted in the steckling nursery at Fort Collins this coming year. Individual mother roots will be selfed in Masonville, CO, taking advantage of pseudo self-fertility, and the selfed seed used to progeny test for resistance to *Cercospora* leaf spot. This population will be recombined and selected for both sucrose content and increased leaf spot resistance.

Genetic information developed during this research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, register, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugarbeet breeders.

**Development of Cercospora Leaf Spot Resistant Germplasm  
with Resistance to Rhizoctonia Root Rot and the Root Maggot.**

L. Panella<sup>1</sup>, L. G. Campbell<sup>2</sup>, & G. A. Smith<sup>2</sup>

<sup>1</sup>Geneticist, USDA-ARS Crops Research Laboratory , Fort Collins, CO

<sup>2</sup>Geneticist, Geneticist & Research Leader, USDA-ARS Northern Crop Science Lab,  
Fargo, ND

Twenty advanced breeding lines or Cercospora-resistant germplasms from Fargo were evaluated at the ARS leaf spot nursery at Ft. Collins (Table 3). FC907, a multigerm, leaf spot resistant germplasm, is being increased and should be released this coming year. This is a cross between FC701 and FC607, which was backcrossed four times to the leaf spot resistant parent (FC607). It has shown excellent Cercospora leaf spot resistance in the last three years of testing.

This Cercospora leaf spot-resistant, multigerm parent developed in Fargo has been crossed with FC709-2, a Rhizoctonia and Cercospora resistant multigerm pollinator germplasm from Fort Collins. This population will be a source of self-incompatible lines with excellent root rot and leaf spot resistance. Seed from this F<sub>1</sub> hybrid was increased in the greenhouse at Fort Collins and will be planted in the steckling field in 1997. This population will be tested as an F<sub>2</sub> in the leaf spot and root rot nurseries at Fort Collins, and individual mother roots reselected next year, dug from the steckling field, will be random mated and individually harvested in the greenhouse. Seed from these plants will be reselected for leaf spot and root rot resistance.

The F<sub>1</sub> hybrid of FC907 x FC709-2 is being crossed with root maggot-resistant germplasm in the greenhouse in Fargo. The resultant population will be selected to produce plants that have combined resistance to leaf spot, root rot, and root maggot.

Genetic information developed previously in our research will be used to execute additional cycles of pathogen inoculation, plant selection, and recombination among germplasms that we have in our leaf spot improvement program. Results of these tests will be the basis of decisions about specific germplasm, i.e., retain, shelve, discard, recombine, release, register, etc. Germplasms likely to be useful for variety improvement will be identified and released for use by other sugarbeet breeders.

The seed from the above mentioned populations will be developed and advanced after testing. Development of a resistant germplasm line generally takes 7 years. A longer time may be necessary to incorporate multiple disease resistances. In an established program, a "pipeline" of lines in various stages of development and evaluation is the norm. Hence, the release of new germplasm usually occurs every 2 to 4 years.

**EVALUATION OF CONTRIBUTED LINES FOR RESISTANCE TO  
*CERCOSPORA BETICOLA*, CAUSAL FUNGUS OF CERCOSPORA LEAF  
SPOT  
(BSDF Project 904)**

**1996 Evaluations of Contributor Lines for Reaction to *Cercospora beticola***

E. G. Ruppel & L. Panella

Randomized complete-block designs, with three replications were used to evaluate breeding germplasm. Internal controls included a highly susceptible synthetic and a resistant check, FC(504 X 502/2) X SP6322-0. Two-row plots were 4 m (12 feet) long, with 56 cm (22 inches) between rows and 20- to 25-cm (8-10 inches) within-row spacing. Although we encountered severe weather initially, our epidemic developed nicely and we obtained excellent results in most experiments. Our first inoculation was delayed until June 29 because of rain and a wet field. We began the inoculation procedure on June 28, but a downpour of rain halted our efforts. Fortunately, hot, dry conditions after the rain (Figure 1) permitted the inoculation to be completed on the 29th. The second inoculation was to be done on July 3, but a severe hail storm shattered leaves so badly that we postponed it until July 11 to allow the plants to recover somewhat. Despite our weather problems, the epidemic progressed favorably due to the warm days and nights, and we rated lines on August 27 and September 3 and 10.

The peak of the epidemic occurred close to the last rating date. On that date, means of the resistant and susceptible internal controls were 4.4 and 6.1 (scale of 0-10), respectively, across the nursery. In 1995 (September 14), these means were 3.9 and 5.9, respectively. Means of contributor lines on September 10 ranged from 2.0 to 7.8, compared with 3.8 to 7.2 in 1995.



## GENETIC DIVERSITY PRESENT IN CULTIVATED AND WILD *BETA* GERMPLASM (BSDF Project 442)

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### Discussion of the Problem

The amount of genetic diversity in a population depends on many factors. A few factors include: inbreeding, plant reproductive system, environment, diversity in founding population, time that population has been in existence, and gene immigration. Within a hybrid parent, less diversity means a more uniform hybrid; however, the more genetic diversity between the hybrid parents, the greater the heterosis seen in the resultant hybrid. The amount of diversity present in a wild population determines the number of individuals that need to be sampled in each population and the total number of populations that ought to be sampled to adequately represent the genetic diversity contained in those populations. It also indicates the population size that needs to be grown out to maintain the total genetic diversity originally present in a population.

The relationship between two inbreds, lines, or populations can be defined in terms of genetic distance. Knowledge of genetic distances among genotypes within germplasm sources is critical for the continued success of plant breeding programs. Conservation methods for crop germplasm may also be affected by genetic relationships among commercial and breeding lines. Although pedigree information and taxonomic studies provide useful information for plant breeders interested in questions of genetic diversity, the ability to utilize DNA technology, such as molecular markers, provides a more accurate and reliable glimpse into these genetic relationships.

We recently have conducted several investigations in our laboratories to better understand the genetic relationships among beet breeding lines, open-pollinated populations, and hybrids. These investigations have demonstrated substantial genetic variation among and within populations in beet genotypes. For example, the Madison laboratory screened 12 individuals from each of 45 open-pollinated lines of red beet with a series of RAPD primers to assess genetic distance among and within lines. Analysis of these data is currently in progress; however, preliminary findings suggest substantial variability within populations. This, in turn, suggests that preservation and utilization of some of our more variable open-pollinated populations may represent large amounts of the genetic diversity in cultivated genotypes. In addition, these studies have afforded the opportunity to examine genetic relationships across different pools of cultivated germplasm. Although data analysis is not complete, clustering of various line types is apparent, indicating genetic distance estimates among these genotypes will reveal useful information for future breeding efforts.

This information can in turn be used to plan crosses and, perhaps, maximize genetic diversity and heterosis. Moreover, molecular markers have been used to assess the relationship among species in the genus *Beta*, providing a clearer phylogenetic picture of this group of plants. **Sugarbeet breeders would benefit from knowledge of the genetic relationships in all of the germplasm pools that are easily accessible through traditional hybridization techniques.** At present, little information regarding genetic distance among cultivated sugarbeet genotypes has been conducted. The objective of this investigation is to assess genetic distance within and among cultivated breeding lines and wild

accessions of *Beta*.

### Short Summary of Literature

Nienhuis and colleagues outlined the uses of molecular markers in assessing genetic relationships among genotypes. These workers concluded that the usefulness of these markers is promoted by their (1) large numbers, (2) lack of environmental interaction, and (3) ability to be organized into linkage groups. In a number of cases, estimates of genetic relationships determined through marker-based distance calculations have correlated well with plant performance and pedigree. Dos Santos and co-workers recently determined that both RAPDs and RFLPs are useful tools for discriminating among genetic relationships in *Brassica oleraceae*. These workers concluded that little difference in genetic distance estimation between these marker systems was found. In general, recent research has revealed both marker systems give reliable and repeatable estimates of genetic distance among groups of commercial lines, populations, and breeding lines.

Distance measures with molecular markers generally are based on a presence/minus basis. With two inbreds, four types of matches between the inbreds are possible: presence of the band in both inbreds (1-1), presence of a band in one inbred but not in the other (1-0 and 0-1), and absence of the band in both inbreds (0-0). Matrices developed from these data may be analyzed with a number of different distance measures, including those summarized by Dudley: the simple matching coefficient, Nei and Li's coefficient, Gower's coefficient, and Rogers' distance. Each of these methods has been used successfully to measure genetic distance among cultivated accessions of crop plants.

The development of RAPD technology has increased the efficiency of evaluating marker linked regions of the genome. RAPD markers, which are generated as a result of polymerase chain reaction-based amplification of genomic inverted repeats, are extremely useful in development of highly-saturated genetic linkage maps in many plant and animal species. Results of recent investigations in sugarbeet revealed substantial amounts of random amplified sequence polymorphism with a small number of random sequences among cultivated genetic materials. This finding suggests the likelihood of detecting sufficient random amplified sequence variation in sugarbeet for identification of useful RAPD marker loci in this investigation. Eagen and Goldman have demonstrated the utility of RAPD technology in assessing marker frequency changes across cycles of recurrent selection in red beet. In addition to these findings, these workers have identified a number of RAPD primers that amplify beet DNA with clarity and accuracy. It is the aim of the Madison program to use these markers in the proposed study.

RFLP Markers exhibit varying degrees of efficacy for detecting differences among taxa within the genus *Beta*. These markers have been used to create a saturated linkage maps of the sugarbeet genome: (1) using  $F_2$  progeny from an intraspecific cross within the sugarbeet genepool and (2) based on an  $F_1 \times F_1$  intraspecific population. Another, more recent, study by Hjerdin and colleagues examined cross hybridization of probes using different stringencies in the hybridization protocol. These researchers calculated an index of variation based on the probability that two accessions, randomly chosen from a group, would have different phenotypes for a particular probe. These studies all indicate the usefulness of some RFLP markers within the sugarbeet genepool and of many markers between *Beta vulgaris* and other species within and outside of the section *Beta*. RFLP markers received from Drs. Jung & Steinrücken in Germany are being used in the program at Fort Collins.

They mark each chromosome arm of the sugarbeet genome in the linkage map produced by Pillen and co-workers. These RFLP markers will be used in this study.

**OBJECTIVE:** The objective of this investigation is to assess genetic distance within and among cultivated sugarbeet breeding lines and other cultivated and wild *Beta* accessions within section Beta to provide necessary information to sugarbeet breeders and *Beta* curators using this germplasm.

### Materials and Methods

Samples of 60 seeds from each of six populations will be sown in greenhouse pots. Leaf tissue from 28-day old seedlings has been harvested from each line, frozen in liquid nitrogen, and freeze dried. DNA has been isolated from finely ground samples of dried tissue using standard protocols developed in our laboratories. One open-pollinated and one inbred table beet line were grown at Madison, the DNA extracted there and shared with Fort Collins. One cross-pollinated and one inbred sugarbeet line were grown at Fort Collins, the DNA extracted there and shared with Madison. One annual and one biennial *Beta vulgaris* subsp. *maritima* accession need to be grown and extracted. Both locations will analyze all of the 360 samples.

**Madison:** A series of oligonucleotide primers (Operon Technologies) of primarily 10 base pair length is being used to direct amplification of discrete genomic regions via the polymerase chain reaction. Amplification products will be analyzed by gel electrophoresis and visualized by ethidium bromide staining.

**Fort Collins:** Eighteen RFLP probes from a PstI digest of a sugarbeet genomic DNA have been received from Dr. C. Jung at the Institut für Pflanzenbau und Pflanzenzüchtung in Kiel, Germany and Dr. G. Steinrücken at the seed company A. Dieckmann-Heimburg in Germany. They are from a library used to produce a saturated linkage map of the sugarbeet genome, and each probe marks one of the sugarbeet chromosome arms ( $2n = 2x = 18$ ). They were received in the form of plasmid DNA (Bluescribe M13<sup>+</sup> vector<sup>®</sup> from Stratagene) and are transformed into *E. coli*. The probes have been labeled with digoxigenin, which is used in conjunction with the Genius<sup>®</sup> System for RFLP detection. This non-radioactive labeling technique uses a chemiluminescent reaction and exposure to X-ray film to visualize the RFLPs.

RAPD markers will be scored for the presence or absence of corresponding DNA band for each primer. RFLP markers will be scored for the presence or absence of DNA bands for each probe, allelic information will be used when available. Statistical analysis will be performed on the combined data obtained from all locations.

### Research Progress 1996

Madison, WI - A large number of beet accessions, including Pis, inbred lines, hybrid cultivars, and open-pollinated populations, have been evaluated for RAPD polymorphisms using 10-base pair primers (Operon Technologies, Alameda, CA). Twenty primers were scored for 7 to 13 polymorphic bands per primer, resulting in a total of 201 RAPD bands. In general these data suggest that for most accessions large amounts of RAPD polymorphism are present.

DNA has been isolated from 50 individual plants of a red beet open-pollinated line and 50 individual plants of a red beet inbred line, Ruby Queen and W357B. PCR Amplification reactions have been successfully performed on a sample of these materials with 7 RAPD primers. Bands were visualized via ethidium bromide staining. Twenty-five RAPD primers will be screened prior to assembling the data set.

**Fort Collins, CO** - DNA has been isolated from 52 individual plants of a sugarbeet cross-pollinated line (FC703) and 52 individual plants of a sugarbeet inbred line (52-305CMS). Eighteen RFLP probes and four mini-satellite probes have been labeled with digoxigenin, which is used in conjunction with the Genius<sup>®</sup> System for DNA hybridization and RFLP detection. This labeling method has been used with a chemiluminescent detection system on a sample of plants from these two sugarbeet lines. Polymorphisms were detected by some probe/enzyme combinations among plants within these lines.

### **Future Plans**

The extracted DNA will be evaluated at both locations and then samples exchanged. DNA from one annual and one biennial *Beta vulgaris* subsp. *maritima* accession will be grown at Fort Collins and the DNA extracted from 60 individuals of each accession. These samples will then be evaluated at both Fort Collins and Madison. Data then will be analyzed and genetic variation within and between populations calculated.

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## WORLD BETA NETWORK

Lee Panella

Collections of primitive sugarbeet landraces, heritage sugarbeet varieties, other cultivated forms of beet (including chard), wild beets, and wild relatives of beets are important genetic resources for the sugarbeet breeder. Genes for disease resistance, stress resistance, and yield and quality components can be found in these plants and incorporated into commercial varieties. The World *Beta* Network (WBN) was founded by commercial and public researchers concerned about losses of these genetic resources and under-utilization of the collections containing these resources. It was organized in 1989 by the International Plant Genetic Resources Institute (IPGRI - formerly IBPGR) as an attempt to bring researchers, curators, and germplasm users from both developed and developing nations together to help manage and plan research to solve problems involving *Beta* genetic resources.

As reported last year, the 4<sup>th</sup> International *Beta* Genetic Resources Workshop and World *Beta* Network Conference was held February 28<sup>th</sup> through March 3<sup>rd</sup>, 1996 in Izmir, Turkey. The meeting was hosted by Drs. A. E. Firat and A. Tan of the Aegean Agricultural Research Institute in Izmir. The meeting was attended by 27 scientists representing 17 countries. There were three scientific sessions, which covered Biosystematics and taxonomy, Genetic diversity, and Genetic diversity and pre-breeding. Manuscripts resulting from this meeting are currently being reviewed and it is hoped that the proceedings will be published by IPGRI this coming fall.

Funding for this meeting was provided by IPGRI, Italy; AGRA, Italy; Dieckmann-Heimburg, Germany; van der Have, the Netherlands; and Kleinwanzlebener Saatzucht AG (KWS), Germany. BSDF covered the costs of the tele-conferencing that was necessary to plan this meeting. The current Beta Coordinating Committee (BCC) of the WBN consists of the permanent secretary, Dr. Lothar Frese at the Institut für Pflanzenbau in Braunschweig, Germany; Dr. Michael Asher at IACR-Broom's Barn in the United Kingdom; Prof. Yi-Chu Sun at the Chinese Academy of Agricultural Sciences, Hulan County, China; and Dr. Lee Panella at the USDA-ARS Crops Research Laboratory in Fort Collins, USA.

The next WBN meeting will be in Broom's Barn, UK in summer or fall of 1999. This is an exciting location with a strong emphasis on sugarbeet research and the screening of *Beta* germplasm.. The BCC appreciates the continued support of the American sugarbeet research and user communities and the BSDF.

## SUGARBEET RESEARCH

1996 Report

### Section C

USDA, ARS, Western Regional Plant Introduction Station  
Pullman, Washington

Dr. Richard Hannan, Research Horticulturist  
Dr. Alan Hodgdon, *Beta* Curator

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This research was supported in part by funds provided through the  
Beet Sugar Development Foundation (Project 290)



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**Status report on the *Beta* germplasm collection activities  
at the USDA, ARS, Western Regional Plant Introduction Station  
To the Beet Sugar Development Foundation  
Curator: Dr. Alan Hodgdon, 1997**

There are 685 accessions on the priority list for seed increase and evaluation. This list may change as a result of germination tests and further work with the inventory. There are 93 accessions of the hard seeded species. Ten of these have been started. Increases have been completed on 75 accessions and there are now 76 in progress. PI'S 120697, 152491, 264349, 264350, 486362, 486363, 504180, 504188, and Ames 4427, and Ames 4429 are critically low.

The Beta seed increase program at Pullman in the last two years has had mixed results. The harvest 96 table at the end of the report is a good example. The Central Ferry (CF), a low elevation site, increases were fair to good. The low plant numbers for some of the accessions were due to insect and irrigation problems and poor germination. At CF 21 plots were carried over to the 1997 season. Most (20) of these accessions appear to be doing well. The greenhouse isolation increases had generally good results. The low plant numbers for some accessions were due to poor germination. Recent increases in the greenhouse system have been quite good. This method of increase, however, is the most expensive. The Pullman site increases have been fair to poor. The main problems at the Pullman location are cold winter weather and insect control. Winter survival at the Pullman site is poor, and flowering induction is erratic. Hillesog company in Europe is increasing 13 of our accessions. On our priority list there 88 accessions that are suitable for industrial increase.

	<b>Increase Activity</b>		
	<i>Started</i>	<i>Harvested</i>	<i>Carry Over</i>
Beta 95	94	69	20
Beta 96	62	11	46
Beta 97	29	0	29
Hillesog	13		13

There are a number of projects in progress at W-6. We are working on an irrigation system for the CF site for use in the isolation tents. This will be in place for the summer of 1997. We are doing lighting trials to improve flower induction which has been a major problem in the increase program in both the field and greenhouse.

Seed inventory backup has been given a high priority. All backup of our collection for NSSL has been completed. We now have a freezer room for long term seed storage. Regeneration samples for most accessions have been identified and packaged for freezing. These will be bar coded and then frozen.

We have started germination tests of some accessions on the increase priority list. Among these are 46 accessions mostly 1987 and 1988 increase seed that are listed as low germ. If some of these are good seed they will be taken off of the priority list. We will also test some 1993 increase seed that apparently had zero to poor viability. We will also do germination tests on seed from our 1996 harvest. In the future, we will conduct baseline germination tests on all harvested seed.



# **SUGARBEET RESEARCH**

## **1996 Report**

### **SECTION D**

Northern Crop Science Laboratory, Agricultural Research Service,  
U.S. Department of Agriculture, Fargo, North Dakota

#### **SUGARBEET AND POTATO RESEARCH UNIT**

Dr. G. A. Smith, Research Leader, Geneticist  
Dr. L. G. Campbell, Geneticist  
Mr. J. D. Eide, Plant Physiologist  
Ms. R. L. Stolzenberg, Microbiologist  
Dr. J. J. Weiland, Plant Pathologist  
Dr. C. A. Wozniak, Molecular Biologist

Dr. J. E. Anderson, Plant Physiologist  
Dr. E. C. Lulai, Chemist  
Dr. P. J. Orr, Agricultural Engineer  
Dr. J. C. Suttle, Plant Physiologist

#### *Cooperation:*

Sugarbeet Research and Education Board of MN and ND  
University of Minnesota, Crookston  
North Dakota State University

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*This research was funded in part by members of the Beet Sugar Development Foundation for support of Projects 601, 610, 630, and 641.*



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## PUBLICATIONS

### *Abstracts of Papers Presented, Published or Approved for Publication*

**Campbell, L. G., A. W. Anderson, R. Dregseth and L. J. Smith. Yield loss associated with sugarbeet root maggot damage. 1996 Sugarbeet Research and Extension Reports, p. 215.**

The sugarbeet root maggot was first recognized as a problem in the Red River Valley in 1947 and continues to be the major insect pest of sugarbeets 50 years later. The primary control method has been the use of planting-time insecticides directed toward reducing larva populations in sugarbeet fields. The effectiveness of insecticides in reducing populations is hindered by the mobility of the adults and the ability of a number of weed species to serve as hosts. This report summarizes the variability in effectiveness of commonly used control measures and examines the relationship between visual damage ratings and yield loss attributable to root maggot damage. Forty-two insecticide trials conducted over a 10-year period at five locations provided a large sample of environments for observation.

**Campbell, L. G., A. W. Anderson, L. J. Smith, and R. Dregseth. Root yield losses associated with sugarbeet root maggot damage. 29th General Meeting of the American Society of Sugar Beet Technologists Abstracts, p. 4.**

Sugarbeet root maggot, *Tetanops myopaeformis*, is the major insect pest of sugarbeet in Minnesota and Eastern North Dakota. Root maggot damage is routinely rated on a 0 (no damage) to 5 (severe) scale. Forty-two trials were utilized to examine the relationship between visual damage and root yield. The mean damage rating in the absence of insecticides was 3.3, compared to a mean of 1.7 for the highest yielding treatment in each trial. Mean root yield of the highest yielding treatment in each trial was 48.8 Mg ha<sup>-1</sup>, compared to a mean of 29.0 Mg ha<sup>-1</sup> when no insecticides were applied. Regression analyses within individual trials indicated the yield loss associated with each increment of the damage rating scale fluctuated widely, ranging from near zero to 15.7 Mg ha<sup>-1</sup>. The percent yield reduction in the absence of insecticides ranged from 9.8% to 83.6% when compared to the treatment providing the most effective control in each test. The regression equation from a combined analysis indicated that little or no yield loss occurs with damage ratings below 1.4. These results are useful in estimating losses, developing recommendations, and providing a standard of comparison for alternative control strategies.



**Campbell, L. G., A. W. Anderson, R. Dregseth, and L. J. Smith. Association between sugarbeet root yield and sugarbeet root maggot (Diptera: Otitidae) damage. *J. Econ. Entomol.* (submitted).**

Sugarbeet root maggot (*Tetanops myopaeformis* von Roder) is a major insect pest of sugarbeet throughout much of North America. Root maggot damage is routinely rated on a 0 (no damage) to 5 (severe) scale. Forty-two trials were utilized to examine the relationship between visual damage and root yield. The mean damage rating in the absence of insecticides was 3.3, compared to 1.7 for the highest yielding treatment in each trial. Mean root yield of the highest yielding treatment in each trial was 48.8 Mg ha<sup>-1</sup>, compared to a mean of 29.0 Mg ha<sup>-1</sup> when no insecticides were applied. Regression analyses within individual trials indicated that the yield loss associated with each increment of the damage rating scale fluctuated widely, ranging from near zero to 15.7 Mg ha<sup>-1</sup>. The percent yield reduction in the absence of insecticides ranged from 9.8% to 83.6% when compared to the treatment providing the most effective control in each test. These results are useful in estimating losses, developing recommendations, and providing a standard of comparison for alternative control strategies.

**Smith, G. A., L. G. Campbell and H. A. Lamey. Current status of triphenyltin hydroxide tolerance in *Cercospora beticola* in Minnesota and North Dakota. 29th General Meeting of the American Society of Sugarbeet Technologists Abstracts, p. 46.**

Triphenyltin hydroxide (TPTH) has been used extensively since 1981 in southern Minnesota and the southern Red River Valley of Minnesota and North Dakota following the development of resistance to the benzimidazole fungicides. Bugbee first reported *Cercospora beticola* L. strains tolerant to TPTH that were isolated from sugarbeets grown in southern Minnesota in 1994. In 1995, Bugbee surveyed TPTH tolerance in leaf spot samples submitted by agriculturalists in the seven factory districts of southern Minnesota and the Red River Valley; from south to north they were Renville, MN; Wahpeton, ND; Moorhead, MN; Hillsboro, ND; Crookston, MN; East Grand Forks, MN and Drayton, ND. The highest level of TPTH tolerance was in the Renville factory district in southern MN, followed by the Wahpeton district in the southern Red River Valley. In the Renville district 96% of samples were tolerant to 0.2 ppm TPTH and 93% were tolerant to 1 ppm TPTH. In the Wahpeton district 82% of samples were tolerant to 0.2 ppm TPTH and 68% to 1 ppm TPTH. In the Moorhead district, 18% of samples were tolerant to 0.2% TPTH and 15% to 1 ppm TPTH. Only a few TPTH tolerant samples were found north of Moorhead in 1995. Surveys in 1996 by Smith and Campbell revealed that TPTH tolerance was much more common farther north than in 1995. In 1996, 96% of Renville samples were tolerant to 0.2 ppm and also to 1 ppm TPTH, 95% of Wahpeton samples were tolerant to 0.2 ppm TPTH and 90% to 1 ppm TPTH, 80% of Moorhead samples were tolerant to 0.2 ppm TPTH and 60% to 1 ppm TPTH, 70% of Crookston samples were

tolerant to 0.2 ppm TPTH and 37% to 1 ppm TPTH and 42% of Drayton samples were tolerant to 0.2 ppm TPTH. In contrast to percent samples, the percent of leaf spots with tolerance to 0.2 ppm TPTH ranged from 80% at Renville to 10% at Drayton.

**Smith, G. A., L. G. Campbell and H. A. Lamey. A survey for the prevalence and distribution of *Cercospora beticola* tolerant to triphenyltin hydroxide and resistant to thiophanate methyl, 1995-1996. 1996 Sugarbeet Research and Extension Reports, p. 261-262.**

Triphenyltin fungicides (hydroxide, chloride, or acetate) have been very effective against *Cercospora beticola* L. for the control of leaf spot on sugarbeet. Triphenyltin hydroxide (TPTH) is superior to copper and carbamate fungicides in toxicity and persistence on leaves and has been used extensively in the Northern Plains of the United States, where *Cercospora* leaf spot is a problem. TPTH usage increased dramatically after the rapid development of strains that became resistant to the benzimidazole class of fungicides in the early 1980's in Minnesota and North Dakota. TPTH now is the primary fungicide for control of *Cercospora* leaf spot on sugarbeets. We began testing field isolates of *C. beticola* in our laboratory in 1986 for tolerance to TPTH and obtained negative results until 1994. Tests of conidia from leaf spots suggested that the fungus had developed tolerance to the fungicide. In 1995 and again in 1996, extensive surveys were made in the Red River Valley and Southern Minnesota extending to the Canadian border. Leaf samples were collected from fields in seven factory districts. These samples were tested in the USDA-ARS laboratory at Fargo to determine the prevalence and distribution of strains of *C. beticola* exhibiting tolerance to TPTH as well as resistance to benzimidazole-type fungicides represented by thiophanate methyl (TM).

**Smith, G. A., J. D. Eide, L. G. Campbell, and L. J. Smith. Biological control of *Tetanops myopaeformis* (sugarbeet root maggot) using the entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae*. 29th General Meeting of the American Society of Sugar Beet Technologists Abstracts, p. 46.**

Sugarbeet root maggot is the most serious insect pest affecting sugarbeets in the upper Midwest. Potential loss of chemical controls and variable results with chemical controls led us to examine biological control measures. Our previous laboratory studies have shown the efficacy of the entomopathogenic fungi *B. bassiana* and *M. anisopliae* on first and third instar sugarbeet root maggots (SBRM). The fungi are also effective against adult flies. Six days after inoculation, mortality rates were 100% for *M. anisopliae* treated flies and 65% for *B. bassiana* treated flies. A three-year field study was initiated with *M. anisopliae* to determine persistence of the fungi over seasons and rotations. Autoclaved barley inoculated with *M. anisopliae* was dried and applied in the

spring, fall, or fall plus spring in replicated field plots at Crookston, MN. Sugarbeets inoculated in the fall plus spring had significantly less damage than the control plots and had significantly greater recoverable sugar per acre (8073.6 lbs per acre) than the controls (6320.8 lbs. per acre). These plots also produced more recoverable sugar than Lorsban-treated plots, which averaged 7747.5 lbs per acre. The first year of field data shows that *M. anisopliae* applied in the right combination is as effective in controlling the SBRM as recommended chemical control.

**Weiland, J. J. Rapid procedure for the extraction of DNA from fungal spores and mycelia. *Fungal Genetics Newsletter* (submitted).**

A method is described for the reliable preparation of DNA from fungal spores and mycelia and from plant tissues. A number of fungal and plant species were used in the study to indicate the generality of the method. The DNA prepared by this protocol was able to be digested by restriction endonucleases and to serve as a template using standard polymerase chain reaction conditions.

**Wozniak, C. A. and L. D. Owens. Tungsten-mediated hydrolysis of  $\beta$ -glucuronide substrates following microprojectile bombardment. 29th General Meeting of the American Society of Sugar Beet Technologists Abstracts, p. 55.**

Metal microcarriers of gold, silicon carbide and tungsten are used in microprojectile bombardment for the introduction of DNA into plant cells. During the development of a transformation protocol for sugarbeets, it was noted that a blue precipitate was formed following the use of tungsten microcarriers in the absence of *gusA* DNA, which encodes  $\beta$ -glucuronidase (GUS). Further evaluation indicated that tungsten microspheres were capable of catalyzing the hydrolysis of X-gluc, salmon X-gluc, and magenta X-gluc, the histochemical substrates used for detection of GUS. Tungsten microspheres accelerated into sugarbeet cells resulted in a blue precipitate when X-gluc assays were prolonged (>24 hours) and gave rise to blue-stained cells. The fluorogenic substrate 4-methylumbelliferyl  $\beta$ -D-glucuronidase (MUG) was similarly hydrolyzed in the presence of tungsten microspheres in the absence of DNA. Gold microspheres and silicon carbide fibrils did not result in hydrolysis of any of the  $\beta$ -glucuronide substrates tested. Incubation of MUG with millimolar concentrations of  $\text{Cu}^{2+}$ ,  $\text{Fe}^{2+}$  and  $\text{Zn}^{2+}$  also resulted in hydrolysis. Heat and protease treatments of tungsten microcarriers, along with standard microbiological analysis, ruled out the presence of contaminating proteins and microbes, respectively. Attention to the use of tungsten microcarriers, metal ions of Cu, Fe and Zn at millimolar concentrations, and the length of incubation during histochemical assays is indicated. The use of DNA-minus and microcarrier-minus controls is recommended when using tungsten microspheres.

**Wozniak, C. A. Transgenic sugarbeets: Progress and development. In V. Malik (ed.), Biotechnology and Genetic Engineering of Plants (submitted for publication).**

The introduction of foreign DNA into sugarbeet has been actively pursued since 1984. When contrasted with other crop species, sugarbeet has been considered resistant to standard genetic engineering techniques. Despite many successes in the production of transgenic or genetically engineered cells and tissues, with some whole-plants regenerated from tissue culture, routine transformation has long been elusive. Protocols based upon *Agrobacterium tumefaciens*, microprojectile bombardment and other DNA transfer methods have been applied successfully to produce transgenic lines for breeding programs, largely in the industrial arena. Due to the proprietary nature of much of the work, details of protocols with their successes and failures are often unknown. Recent advances based on the isolation of cells that can regenerate whole plants suggest a promising avenue for a higher frequency of transformation. Resistance to insects, diseases, and herbicides are the primary transgenic types likely to reach commercial production first. Current program developments, including herbicide resistance, could see seed release in 1998. The use of viral coat-protein expression in transgenic sugarbeets has been documented for the control of beet necrotic yellow vein virus and progress is also being made toward development of curly top virus-resistant plants. Antibacterial and antifungal proteins are being recruited as part of a modified plant-defense response. Routine transformation protocols will no doubt broaden the scope of sugarbeet engineering and result in value added traits, such as enhanced sucrose content and the synthesis of biodegradable polymers, that are presently being developed for modification.

**Zheng, Yushi and Wozniak, C. A. Adaptation of a  $\beta$ -1,3-glucanase assay to microplate format. *Biotechniques* (submitted).**

A method is described for performance of the  $\beta$ -1,3-glucanase assay in microtiter plates. Assay samples containing  $\beta$ -glucanase (cell extracts) and the substrate are mixed in 96-well, autoclavable microtiter plates. Incubation of the enzyme-substrate mixture (30  $\mu$ l/well; 37 °C, 20 min) results in the release of reducing sugars by the action of  $\beta$ -1,3-glucanase. The levels of these sugars are colorimetrically quantified through the addition of copper reagent and neocuproine, incubation at 100°C for 10 minutes and the resulting reduction of  $\text{Cu}^{++}$  to  $\text{Cu}^+$ . A standard curve of glucose concentrations within the same plate allows for assessment of internal variance. Twenty samples can be assayed in one microtiter plate in 1 hour, compared to the 96 test tubes and 4 hours needed for traditional assay methods. The net savings in reagents used with the microtiter format is substantial (approximately 1/125th the quantity of laminarin is required when compared with standard tube formats). The measurement of optical density (OD) is performed rapidly for all of the samples, eliminating the problem of oxidization of  $\text{Cu}^+$  to  $\text{Cu}^{++}$  during quantification. This method represents a significant savings in time, chemicals and cost.



## CERCOSPORA LEAF SPOT AND BIOPESTICIDE RESEARCH

### *Project 601*

Garry A. Smith, John D. Eide and Larry G. Campbell

The gene and gene products involved in *Cercospora* resistance are being examined. Purification of the PR proteins chitinase and glucanase from leaf spot resistant (LSR) leaves was accomplished using differential centrifugation, ammonium sulfate precipitation, and affinity chromatography. The apparent molecular weight of glucanase as determined by SDS-polyacrylamide gel electrophoresis was 26 and 29 kDa. Isoelectric focusing determined an isoelectric point of 4.9. Samples were lyophilized and pooled in preparation for antibody production.

A 26 kD glucanase was purified by chromatography and electrophoresis. The glucanase protein was transblotted to PVDF membrane for amino acid sequencing. The N-terminal amino acid sequence is as follows: H<sub>2</sub>N- Thr Thr Phe Thr Val Val Asn Asn Cys Gln. This sequence will be used to construct a nucleic acid probe for detection of antifungal genes in sugarbeet. A nucleic acid probe would be useful to study the regulation of antifungal glucanase genes.

We have begun a new method for determination of the presence of chitinase genes in LSR, leaf spot susceptible (LSS) and wild Beta germplasm. Total nuclear DNA was isolated from *Beta vulgaris*, *B. webbiana*, *B. atriplicifolia*, *B. patellaris*, *B. trigyna*, *B. procumbens*, *B. lomatazona*, and *B. corolliflora* leaves. The polymerase chain reaction (PCR) was used to amplify the DNA sequence complementary to the SE2 chitinase gene. The following PCR primers were used to generate a 476 bp DNA fragment: 5' ACAAATTGTAA-CAGTCTGAGCAGT 3', 5' GAAGATCTGGTTAGCTTGTACTGT 3' complementary to SE2 acidic chitinase. Using PCR, the primers detected the SE2 chitinase gene in all beets grouped into the Beta and Corollinae sections including Cercospora leaf spot resistant check, leaf spot susceptible check (*Beta vulgaris*), *Beta maritima*, *B. atriplicifolia*, *B. corolliflora*, *B. trigyna*, *B. lomatazona* and *B. macrorrhiza*. PCR detected no 476 bp fragment in the Procumbens section of beets containing *B. patellaris*, *B. webbiana* and *B. procumbens*.

## SUGARBEET ROOT MAGGOT BIOPESTICIDE RESEARCH

### *Biopesticide Laboratory Work*

*Beauveria bassiana* and *Metarhizium anisopliae* are being tested as biocontrol agents for control of *Tetanops myopaeformis* (sugarbeet root maggot). Loss of chemical controls and variable results with chemical controls led us to examine biological control measures. Our previous studies have shown the efficacy of the entomopathogenic fungi *B. bassiana* on first and third instar sugarbeet root maggot (SBRM). Exposure of third instar larvae to *M. anisopliae* resulted in 94% mortality 15 days post-inoculation. The fungi are also effective against adult flies. Six days after inoculation *M. anisopliae* treated flies had 100% mortality vs. 65.7% for the *B. bassiana* treated flies. Molecular techniques are facilitating the development of a fungal biopesticide. We have developed a method for isolation of total DNA from SBRM infected with

entomopathogenic fungi. This DNA is suitable for use in PCR to detect the presence of pathogenic organisms.

We have synthesized primers specific for *Beauveria bassiana*. The primers 5'-AAGCTTCGA-CATGGTCTG-3' and 5'-GGAGGTGGTGAGGTTCTGTT-3' give a positive reaction with the formation of a 524 bp PCR fragment with *B. bassiana* infected SBRM. The control and maggots infected with other fungi gave no reaction. We have compared our DNA isolation techniques with one developed by Dr. John Weiland for isolating plant pathogenic fungal DNA. Both methods have been used to successfully isolate DNA from entomopathogenic fungal strains of *Metarhizium anisopliae*, *Beauveria bassiana*, *M. flavoviride*, *Cordyceps militaris*, *Hirsutella thompsonii* and *Verticillium lecanii*. The latter four fungi are being evaluated for activity against SBRM.

Current detection techniques for entomopathogenic fungi are laborious and inexact. We have been testing PCR primers specific for actin genes for detection of the entomopathogenic fungus *M. anisopliae* (primers provided by Dr. John Weiland). We are preparing a rapid detection method using PCR for strains of fungi entomopathogenic to SBRM. A 1.3 kbp DNA fragment has been synthesized using PCR with primers specific for the 5' end of the actin gene in *M. anisopliae*. This DNA fragment has been isolated and is being cloned and sequenced. We will compare sequences of the maggot pathogenic strain 22099 and others and synthesize primers specific for *M. anisopliae* 22099. These primers will be used for a rapid detection test of *M. anisopliae* in soil, rhizosphere or diseased insects.

Production of *M. anisopliae* conidia on heat-killed barley is being fine tuned. We produced over 2000 pounds of inoculum this past year. We are continuing to examine long-term viability of *B. bassiana* and *M. anisopliae*. The fungi are stable under a range of storage temperatures and times (Table 1).

**Table 1. Viability of *B. bassiana* and *M. anisopliae* under different temperature regimes (+ = still viable, Nd = not determined).**

Fungus Tested	Temperature	Months				
		5	8	21	34	36
<i>M. anisoplaie</i>	20°C	+	+	+	+	+
"	-20°C	+	+	+	+	Nd
"	-80°C	+	+	+	+	Nd
<i>B. bassiana</i>	20°C	+	+	+	+	+
"	-20°C	+	+	+	+	Nd
"	-80°C	+	+	+	+	Nd

## Biopesticide Field Studies

Sugarbeet root maggot is the most serious insect pest affecting sugarbeets in the upper Midwest and in other irrigated areas east of the Rocky Mountains. Potential loss of available chemical controls and variable efficacy suggest that a biological control paradigm should be developed and examined.

Based on our laboratory results and on a one-year field pilot study, a three-year field study was initiated to determine the persistence of *M. anisopliae* over seasons and rotations. Autoclaved barley (as a carbon source) inoculated with *M. anisopliae* was dried and applied in the spring immediately prior to planting, in the fall preceding planting, or in the fall plus spring in replicated field plots. These treatments were compared with 'Lorsban' treated plots as well as control plots without treatment.

The fall plus spring treated plots had significantly higher stand counts than Lorsban treated plots (Table 2). The chemical may be phytotoxic compared to the biocontrol agent. Sugarbeets inoculated in the fall plus spring also had significantly less damage (Table 3). The resulting root yield from the fall plus spring treatment with *Metarhizium* was equal to the Lorsban treatment (Table 4). The fall plus spring treatment with *Metarhizium* resulted in significantly greater recoverable sugar per acre than the controls (8074 lbs. vs. 6338 lbs.). These plots also produced more recoverable sugar than Lorsban-treated plots, which averaged 7748 lbs per acre (Table 5). Since sucrose percentage was not significantly affected by any of the treatments, the increase in recoverable sugar is attributed to increased tonnage.

The first year of field data suggests that *M. anisopliae*, applied in the right combination, may be as effective in controlling the SBRM as the best chemical controls.

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**Table 2. Summary of sugarbeet stands per 100 ft row from a field test of *Metarhizium anisopliae*, Crookston, MN, 1996.**

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Treatment	Stand
Lorsban	110.3c*
<i>Metarhizium</i>	
Fall + Spring	133.2ab
Fall	123.2abc
Spring	138.7a
Nontreated	123.8abc

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\*Values followed by the same letter are not significantly different at the 0.05 probability level.

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**Table 3. Sugarbeet root maggot damage ratings from field test of *Metarhizium anisopliae*, Crookston, MN, 1996.**

Treatment	Damage Rating
Lorsban	3.02a*
<i>Metarhizium</i>	
Fall + Spring	2.90a
Fall	3.40b
Spring	3.61c
Nontreated	4.12d

\*Values followed by the same letter are not significantly different at the 0.05 probability level.

**Table 4. Yield of sugarbeets from field test of *Metarhizium anisopliae*, Crookston, MN, 1996.**

Treatment	Tons Per Acre
Lorsban	26.40a*
<i>Metarhizium</i>	
Fall + Spring	26.26a
Fall	22.96b
Spring	22.69b
Nontreated	22.07c

\*Values followed by the same letter are not significantly different at the 0.05 probability level.

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**Table 5. Feld test of *Metarhizium anisopliae*, Crookston, MN, 1996.**

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Treatment	Recoverable Sugar Per Acre
Lorsban	7748a*
<i>Metarhizium</i>	
Fall + Spring	8074a
Fall	6580b
Spring	6729b
Nontreated	6338b

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\*Values followed by the same letter are not significantly different at the 0.05 probability level.

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# DEVELOPMENT OF A GREENHOUSE ASSAY FOR RESISTANCE TO *RHIZOCTONIA* ROOT ROT

## *Project 610*

Garry A. Smith, Larry G. Campbell, and John J. Weiland

Our previous report noted that the resistance of sugarbeet release FC712 to *Rhizoctonia solani* strain AG2-2 could be detected readily after the inoculation of 5-week-old plants in the greenhouse, as compared to the susceptible control variety, Ultramono.

The following report summarizes a more extensive test of the greenhouse assay for *Rhizoctonia* resistance which examined several germplasm releases inoculated over several dates throughout 1996. The technique briefly summarized is as follows: Plants (one per 6" pot) are grown to the 5-week stage before inoculation. Sterile barley grain is inoculated with *Rhizoctonia solani* AG2-2 is inoculated to and allowed to colonize for 2-3 weeks. The infested grain is used to inoculate the 5-week-old plants; two infested grains are placed together approximately 0.5" below the soil surface and touching the root surface. Soil is replaced over the inoculum grain. Plants are rated for root rot disease at 14 days post-inoculation. Healthy (resistant) plants possess small or no lesions. Previous results indicated that 100% of the plants of a susceptible variety (Ultramono) became diseased and or wilted when subjected to this assay.

The data for the testing of select germplasm in the *Rhizoctonia* greenhouse assay is summarized in Table 1. Several of the FC7XX germplasm (selected for *Rhizoctonia* resistance) were compared to FC907BC, shown to be susceptible in the Fort Collins *Rhizoctonia* nursery. The test clearly demonstrated that susceptible and resistant material for certain inoculation dates tested can be distinguished.

Late spring and summer planting dates in 1996 (6/96 and 8/96 assay dates) yielded greenhouse assay results that are consistent with the lesion ratings obtained at the Fort Collins nursery for the same germplasm accessions. Indeed, a 0.99 correlation was calculated for ratings obtained at Fort Collins in 1995 compared to those for the same lines tested at Fargo in 1996 (8/96 assay date; Table 2), whereas a 0.62 correlation was calculated for ratings at Fort Collins compared to the mean ratings across all assay dates in Fargo.

Resistance in sugarbeet germplasm was not adequately detected after a late winter planting, suggesting to us the involvement of day length in the expression of resistance (Table 1). This will be tested in future experiments using greenhouse plantings supplemented with artificial light as well as plants tested in a controlled growth chamber.

Cultivars and germplasm releases that have performed consistently in the Fort Collins nursery over several years will be included in the 1997/1998 greenhouse trials at Fargo in order to standardize the test. Progeny populations segregating for resistance to *Rhizoctonia* root rot will be subjected to the assay by the end of 1997.

The results to date indicate that cultivar resistance to root rot of sugarbeet caused by *R. solani* may be detected using this rapid greenhouse test.

**Table 1.** Results from 1996 *Rhizoctonia* greenhouse assay.

Accession	Assay Date <sup>a</sup>	%HVP <sup>b</sup>	FCN-1994 <sup>c</sup>	FCN-1995 <sup>d</sup>
FC702-7	4/96	28.7	69.9/1.28	62.1/1.47
	6/96	22.4		
FC703-5	4/96	31.2	78.0/1.36	60.7/1.57
	6/96	40.6		
FC729	4/96	7.3	53.04/1.65	47.22/1.76
	6/96	14.7		
	8/96	79.0		
FC709-2	4/96	10.0	85.73/1.01	55.23/1.5
	6/96	41.0		
	8/96	89.0		
FC726	4/96	4.7	66.92/1.46	50.18/1.54
	6/96	38.1		
	8/96	76.0		
FC607/708 <sup>e</sup>	4/96	8.2	25.78/2.84	
	6/96	7.9		
607cms/708 <sup>f</sup>	4/96	8.4	52.49/1.88	
	6/96	4.5		
FC723	4/96	6.8	41.39/2.02	
	6/96	10.5		
FC724	4/96	16.4	37.77/2.43	
	6/96	12.1		
FC907BC	4/96	4.3		14.31/3.28
	6/96	2.3		
	8/96	1.5		

<sup>a</sup> Readings of plants were taken over several days in the month indicated.

<sup>b</sup> Percent of the vegetative plants (out of 100 - 200 plants) that displayed no or mild (0-1 disease index) disease symptoms.

<sup>c,d</sup> Data from 1994 and 1995 Fort Collins *Rhizoctonia* nursery (percent healthy plants/disease index rating; rating of 0=healthy plant to 7=dead).

<sup>e,f</sup> Progeny of the parent lines shown after 4 cycles of selection for *Rhizoctonia* resistance.

**Table 2.** Correlation of greenhouse and field data: *Rhizoctonia* resistance screening.

Treatment <sup>a</sup>	r <sup>b</sup>	$\alpha$ <sup>c</sup>	n <sup>d</sup>
Greenhouse (8/96)	0.99	0.0002	5
Greenhouse (mean for year) <sup>e</sup>	0.62	0.10	8

<sup>a</sup> Only the greenhouse treatment is listed--both greenhouse treatments were examined for correlation with the data from the 1995 ratings of the same sugarbeet lines in the Fort Collins nursery.

<sup>b</sup> Pearson's sample correlation coefficient.

<sup>c</sup> Level of significance.

<sup>d</sup> Number of lines examined for correlation.

<sup>e</sup> Mean of the ratings within each line and across all two or three assay dates.

# **BROADENING THE GENETIC BASE OF SUGARBEET (PRE-BREEDING)**

## ***Project 630***

**Devon L. Doney and Larry G. Campbell**

The narrow genetic base of most sugarbeet breeding pools has been recognized by sugarbeet breeders as a restriction to progress. Continued progress is, therefore, contingent upon incorporation of genetic variation into breeding propulations. The aim of this project is to incorporate genetic variation from wild populations into sugarbeet breeding pools.

Three sets of crosses with different wild germplasm have been developed as follows.

**Crosses made in 1986:** L53cms X WB's (wild *Beta* mixture); L53cms X *Beta maritima* accession from Greece; and L53cms X *Beta maritima* accession from Italy.

**Crosses made in 1990:** 3747(aa) X *B. maritima* (sample of accessions from Denmark); 3747(aa) X *B. maritima* (sample of accessions from Belgium); 3747(aa) X *B. maritima* (sample of accessions from Ireland); 3747(aa) X *B. maritima* (sample of accessions from the Middle East); 3747(aa) X *B. macrocarpa* (15 accessions); 3747(aa) X *B. patula* (3 accessions); and 3747(aa) X *B. atriplicifolia* (7 accessions).

**Crosses made in 1994:** R376-43 (self incompatible sugarbeet inbred from California) X 50 accessions from the United Kingdom, France, Ireland, Denmark, Belgium and the Channel Islands.

### ***1986 Crosses***

The sugarbeet parent in the 1986 crosses was a cytoplasmic male sterile inbred, L53cms. Resulting populations segregated for male sterility. In each selection cycle, plants were selected for root shape, intercrossed, and seed from male sterile plants harvested for the next generation. By the fourth cycle, roots resembled sugarbeet. Four lines generated from the fifth selection cycle of the L53cms X WB 252 cross were released in 1994. These lines showed good combining ability for root yield but low sugar concentration. Two released lines, y322 and y387, were crossed to L19, a high sugar line. F<sub>2</sub> seed were planted in space-planted trials and individual roots selected for high specific gravity in 1995. Each selected root was selfed and crossed to L33cms.

The selfed seed from each root was planted in a space-planted trial in 1996 and individual roots selected for root shape and percent sugar. Roots from the y322 cross were long and smooth and very near sugarbeet type.

At the same time, the crossed seed from each root was planted in a replicated field trial. The results are given in Tables 1 and 2 (L19 X y332) and 2 (L19 X y387). Insufficient seed resulted

in a limited number of replications (one to three per entry). Data are presented as a percent of the check cultivar, Ultramono, in the replications the entry was grown.

Lines C33 and C61 (Table 1) had sugar percentages and root yields equal to or greater than Ultramono, resulting in increases of 11 and 10 percent total sugar yield over the check hybrid. Other lines varied, with some having higher root yields and some higher sugar percentages than the check, but not both. The mean for all (L19 X y322) X L33 hybrids was similar to the check for Amino-N and loss to molasses; however, most of the lines were lower in sodium and higher in potassium than the check hybrid.

Lines C79 and C138 (Table 2) gave higher root and sugar yields and higher sugar percentages than the hybrid check. Lines C88 and C112 also showed promise; however, they were only represented in one replication.

These data are very promising and warrant continued selection and evaluation in several of the lines. Sugar percentages have increased while maintaining good combining ability for root yield.

**Table 1.** Root yield, sugar percentage, total sugar yield and quality determinations, expressed as a percent of Ultramono, for testcrosses between single plants from the L19 X y322 population and L33cms.

Selection	Reps	Total Sugar (Lbs/A)	Root Yield (T/A)	Sugar (%)	Na (ppm)	K (ppm)	AmN (ppm)	S.L.M. (%)
C33	2	111	105	106	67	110	75	87
C35	2	101	108	94	69	120	104	102
C39	2	84	89	94	60	106	105	96
C44	2	98	99	97	82	103	98	98
C46	2	93	110	86	53	132	119	109
C53	1	110	120	92	118	109	110	112
C61	3	114	115	100	60	105	115	103
C64	3	87	82	106	52	107	79	87
C70	1	92	94	97	69	106	118	108
Mean		99	102	98	68	111	101	99

**Table 2.** Root yield, sugar percentage, total sugar yield and root quality determinations as a percent of Ultramono for testcrosses with single plants from the L19 X y387 population with L33cms.

Selection	Reps	Total Sugar (Lbs/A)	Root Yield (T/A)	Sugar (%)	Na (ppm)	K (ppm)	AmN (ppm)	S.L.M. (%)
C79	2	128	125	104	72	103	110	100
C81	2	87	96	91	118	88	104	100
C84	2	74	80	92	135	88	101	103
C88	1	109	125	87	102	98	129	100
C91	2	95	99	97	78	95	101	95
C93	2	87	90	97	87	95	86	89
C98	2	86	87	100	84	98	104	96
C102	1	71	76	96	77	83	97	87
C105	2	75	76	94	71	96	95	89
C106	1	95	99	95	99	107	108	113
C112	1	107	108	99	70	114	119	105
C132	1	95	94	101	42	105	107	89
C134	1	74	83	94	92	99	124	104
C138	3	105	100	105	107	96	56	79
Mean		90	95	94	84	97	98	95

### *1990 Crosses*

The sugarbeet parent in these crosses was a California line segregating for genetic male sterility. Crosses were made on male sterile segregates. In subsequent intercrosses, seed was also harvested on the male sterile segregates. This maintained the genetic male sterile gene and insured intercrossing. After two cycles of random intercrossing and two cycles of selection for early emergence and early leaf initiation, all populations were grown in a space-planted root-shape selection nursery in 1995. Selected roots were intercrossed and crossed to L33cms for each population. Two lines, one derived from seed harvested from male sterile plants and one derived from seed harvested from non-male sterile plants, were generated from five of the populations. Because of its performance in 1995 trials, selections from one line, A13, were selfed and individually crossed to L33cms. Each of these populations was planted in a space-planted nursery in 1996 and selected for root shape. The crosses of these populations with L33cms were tested in a replicated field trial (Tables 3 and 4).



**Table 3.** Root yield, sugar percentage, total sugar yield and quality determinations as a percent of Ultramono for hybrids of single plants selected from the A13 population crossed with L33cms.

Entry	Reps	Total Sugar (Lbs/A)	Root Yield (T/A)	Sugar (%)	Na (ppm)	K (ppm)	AmN (ppm)	S.L.M. (%)
C160	2	62	75	101	123	95	99	103
C162	2	109	111	99	86	97	106	103
C164	2	83	88	97	108	102	103	102
C166	2	82	83	99	63	91	98	90
C171	2	117	122	97	100	97	91	95
C173	2	89	85	104	61	101	82	84
C176	3	98	99	98	60	93	94	95
Mean		92	95	99	71	96	96	96

The A13 lines had only enough seed for two or three replications; therefore, their data are reported as a percentage of the hybrid check (Ultramono). There were big differences between lines, with lines C162, C166 and C176 showing the most promise. These results are encouraging since this population had only one cycle of selection for root shape. It should be noted that, even though root yields were relatively good, there was considerable sprangling in these lines.

All testcross hybrids (Table 4), although poorer than the commercial hybrids, gave sufficiently promising results as to warrant continued selection. Lines carrying *B. atriplicifolia* germplasm had the best-shaped roots.

**Table 4.** Root yield, sugar yield and sugar percentage for testcross hybrids from the 1990 crosses (3747aa X wild population).

Entry	Cross	Wild Parent	Total Sugar (Lbs/A)	Root Yield (T/A)	Sugar (%)
C18	L33cms X z181	<i>B. maritima</i> (Denmark)	5977	25.1	11.9
C150	L33cms X A9	<i>B. maritima</i> (Denmark)	5075	20.3	12.4
C21	L33cms X z182	<i>B. maritima</i> (Belgium)	7074	28.7	12.3
C152	L33cms X A15	<i>B. maritima</i> (Belgium)	6055	25.2	11.9
C23	L33cms X z183	<i>B. maritima</i> (Ireland)	5906	23.8	12.4
C25	L33cms X A17	<i>B. maritima</i> (Ireland)	6114	26.2	11.7
C140	L33cms X z250	<i>B. atriplicifolia</i>	6477	28.6	11.4
C142	L33cms X z251	<i>B. patula</i>	6626	27.6	12.0
C28	L33cms X z252	<i>B. macrocarpa</i>	6430	29.2	11.1
C157	L33cms X A22	<i>B. macrocarpa</i>	6167	27.7	11.2
C144	L33cms X z253	<i>B. maritima</i> (Middle East)	6724	29.3	11.5
C155	L33cms X A20	<i>B. maritima</i> (Middle East)	6294	29.5	10.7
Check	Mean of 2 Hybrids		7815	30.5	12.9
LSD	0.05		1035	3.9	0.7

### 1994 Crosses

The sugarbeet female in these crosses was a self incompatible sugarbeet line from California. The development of segregating populations from these crosses was as follows: (1) 10 plants from each accession were crossed individually to the self-incompatible sugarbeet line, (2) 10 plants from each F<sub>1</sub> plant (total 100 plants) were intercrossed to generate the F<sub>2</sub> seed, and (3) equal numbers of seeds from each F<sub>2</sub> plant were grown and intercrossed to produce the F<sub>3</sub> seed. This method insured that the genetic variation within each accession was represented in the first selection generation. The first cycle of selection for root shape will be conducted in 1997.

# GENETICALLY-ENGINEERED RHIZOSPHERIC MICROBES OF SUGARBEET IN MANAGEMENT OF SUGARBEET ROOT MAGGOT DAMAGE

*Project 641*

Chris A. Wozniak

*Stenotrophomonas maltophilia* is a common bacterium present on sugarbeet roots and is also considered a symbiont of the sugarbeet root maggot (SBRM). Due to this presence, it has been selected as a vector for insecticidal toxins or feeding deterrents as part of a biological control program for the SBRM. Transformation vectors are not readily available for this microbe and genetic information is minimal compared to many other bacterial groups (*e.g.*, enterobacteria, pseudomonads). The initial emphasis of this work has been on the development of a transfection protocol and identification of suitable replicons for testing of marker genes.

Transfection experiments aimed at introducing novel genes into *S. maltophilia* are underway to identify selectable and screenable markers. The broad-spectrum antibiotic resistance prevalent in *S. maltophilia* has limited the vectors useful in transfection of this bacterium, and only strains with susceptibility to ampicillin (amp) or kanamycin (kan) have, therefore, been tested as recipients. Electroporation experiments using pUC- (amp<sup>r</sup>) and pBIN19-(kan<sup>r</sup>) based vectors have indicated an inability of these plasmid types to replicate within the isolates of *S. maltophilia* examined.

Various  $\beta$ -lactamase and cephalosporinase encoding genes (ampicillin, cephalosporin resistance) are known to reside on the chromosome of this species, as do neomycin phosphotransferase genes (kan<sup>r</sup>). A few strains which differ in this regard were chosen as potential recipients in transfection-optimization experiments. Although plasmids detectable by standard alkaline lysis techniques (*i.e.*, 1-30 kbp) are rare in *S. maltophilia*, we have isolated a 6.5 kbp replicon (pXM222) from a clinical isolate provided by a colleague. Following introduction of pXM222 into JM109 and DH5 $\alpha$  strains of *E. coli*, transfectants were assessed for changes in antibiotic resistance by disc-diffusion assay on Mueller-Hinton medium at 37°C. Resistance to amp, azlocillin, carbenicillin, and cefamandole, but not cefotaxime, was conferred by pXM222. Presence of the plasmid was confirmed by miniprep and agarose gel electrophoresis.

Restriction enzyme digestion of pXM222 was undertaken to prepare a restriction map and subclone fragments for utility testing. Enzymes with single and multiple sites were identified and a partial map constructed. Interestingly, the plasmid XM222 was shown to resolve at 6.5 kbp from some transfectant colonies, whereas in others it was present as a single band at approximately 10 kbp, as judged by comparison to marker fragments that were co-electrophoresed. Several experiments were undertaken to test the stability of this 10 kbp replicon, including the effects of growth temperature and method of plasmid isolation. Use of phenol-chloroform extractions during isolation or growth temperature (30 vs. 37°C) had no influence on plasmid size or integrity. When large scale plasmid preparation was performed on isopycnic CsCl gradients, a single band collected from the gradients resolved as a 10-11 kbp

plasmid when electrophoresed. Plasmids prepared as small scale purifications (minipreps) from *S. maltophilia* strain XM222 migrated as a 6.5 kbp band with a fainter 10-11 kbp band present as well, presumably representing nicked plasmid molecules. One of the DH5a transfectants, however, reproducibly yields a 10-11 kbp plasmid following alkaline-lysis preparation. This would suggest that this plasmid is particularly labile to isolation conditions or contains an excisable element. Experiments are in progress to determine the nature of plasmid instability in these instances.

A second plasmid which is known to replicate in *S. maltophilia* and several other Gram negative bacteria is pJP4 (25 kbp) and the derivative pRO101. Although these plasmids contain markers for mercury and tetracycline (tet) resistance, neither proved to be useful in selection of *S. maltophilia* in that inherent resistance to both seems to be common in this organism. The presence of mercury resistance plasmids in other sugarbeet rhizospheric bacteria has also recently been reported. Nonetheless, we are initiating transfection experiments based on the few available tet-sensitive strains in the culture collection. Fragments of this well characterized replicon will also be subcloned for use in vector construction (*i.e.*, ori) by combining sequences from pJP4 and pXM222 to create a useful plasmid of manageable size (*e.g.*, 5-10 kbp).

The presence of this bacterium in opportunistic hospital acquired infections will require some means of differentiating or separating clinical from environmental strains prior to use in field studies. Previous work with repetitive (REP, ERIC) sequences has shown that these markers, while useful in enterobacterial investigations, are not applicable to *S. maltophilia*. Similarly, the highly conserved 16S-rDNA gene was not useful in that variation among strains was almost non-existent. Our current efforts have been directed toward the use of intergenic spacer sequence (IGS), to which I have already synthesized PCR primers, as a means of grouping strains based on origin.

This work is part of a longer-term approach to management of the SBRM and will continue its progress. Request for funding of a new proposal (novel fungal pathogen of SBRM) was based on the more immediate need for the exploitation of a natural pathogen of SBRM, which should proceed through the patent process in order to expedite licensing for scale-up and application. Of course, our experience with other entomopathogenic fungi compliments this new project.



## **SUGARBEET RESEARCH**

### **1996 Report**

#### **Section E**

Sugarbeet and Bean Research Unit  
Agricultural Research Service, USDA  
East Lansing, Michigan

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#### **Cooperation:**

Michigan Sugar Company  
Monitor Sugar Company

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## ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION

SAUNDERS, J. W. 1996. Notice of release of biotechnology germplasm REL-2.

Clone REL-2 is being released for use in somatic cell selection and genetic transformation systems. REL-2 may also be useful in developing artificial seeding systems. REL-2 is a diploid self-fertile annual clone with N cytoplasm. It is an F<sub>1</sub> individual from a cross of an intensely shoot regenerating individual from monogerm type-O EL-45/2 (a derivative of SLC-133) with REL-1, a tissue culture amenable clone released at East Lansing in 1987. REL-2 is a superior and prolific regenerator of shoots and somatic embryos from callus compared with REL-1, and has less of a tendency to produce vitreous shoots from callus and from shoot cultures than its maternal parent had. REL-2, unlike some of its siblings and REL-1, produces somatic embryos on leaf disc callus in the absence of growth regulators. REL-2 produces plentiful pollen and is easily maintained and multiplied by in vitro shoot culture. REL-2 is heterozygous at the *B* (annual/biennial), *M* (multigerm/monogerm), and *R* (+/- red betalain pigment) loci. It is not known whether REL-2 is type-O, although its mother and paternal grandmother were type-O. REL-2 should be useful for somatic cell selection where REL-1 often failed to produce shoots from selected calli. Because of its prolific primary somatic embryogenesis and shoot regeneration from callus, REL-2 should have superior utility in gene transformation systems. It is expected that new genetic traits produced in REL-2 will have to be backcrossed into more favorable genetic backgrounds before they appear in commercial hybrids.

## ABSTRACTS OF PAPERS PUBLISHED OR APPROVED FOR PUBLICATION

HALLOIN, JOHN M., DAVID J. JOHNSON, DEBRA A. GANOFF, and ALLAN H. LAMMERS. Evaluation of resistance of sugarbeet seedlings to *Aphanomyces cochlioides*: conditions affecting disease severity in a model system. In: Abstracts of the 29th General Meeting of American Society of Sugar Beet Technologists. 3/2-5/97, Phoenix, AZ. p.20.

*Aphanomyces cochlioides* causes damping-off of sugarbeet seedlings throughout U.S production areas. We present a method for uniform production and inoculation of seedlings and evaluation of disease severity. Seeds of a susceptible variety were placed on moist germination papers which were then folded and rolled to form cylindrical "rag dolls"; these were kept under constant light at 22°C for 4 days. Seedlings longer than 5 cm were transferred in groups of 25 to water (controls) or to suspensions of *A. cochlioides* zoospores and incubated for 10 minutes. They were placed in new rag dolls, incubated in growth chambers at 15, 20, 25, or 30°C for 5 days under constant light, and were evaluated for disease development 1, 3, and 5 days after inoculation. Disease severity was rated on a scale of 0 to 4 (0 = no disease, 1 = 1 to 25%, and 4 = >75% of tissue rotted). Inoculated seedlings incubated at 30°C had mean ratings of ca. 4 after 3 days, whereas seedlings at 15°C were moderately diseased (mean score ca. 2) after 5 days. The rate of disease development was intermediate at 20 and 25°C. Occasional symptoms observed on control seedlings usually were attributable to breakage during handling. These methods provide a useful means for assessment of disease development in large populations of seedlings. Future experiments will use these methods to discriminate between resistant and susceptible varieties and to select resistant individuals for breeding purposes.

HALLOIN, JOHN M., ALLAN W. CATTANACH, JOSEPH J. COOMBS, and GARRY A. SMITH. Use of systemic acquired resistance for control of sugarbeet diseases. In: Abstracts of the 29th General Meeting of American Society of Sugar Beet Technologists. 3/2-5/97, Phoenix, AZ. p.20.

Systemic acquired resistance (SAR), disease resistance induced by prior infections or by chemicals that are themselves non toxic, has been demonstrated in numerous crops. Resistance to *Cercospora* leaf spot of sugarbeets was induced by one such chemical in greenhouse experiments (Nielsen, et al., 1994. *Physiol. Mol. Plant Pathol.* 45:89-99). We tested reported resistance-inducing chemicals for control of sugarbeet diseases under field conditions. Experiments in MI in 1995 demonstrated that putative inducers of SAR did not enhance stand density or size of seedlings. Similarly, no decrease in severity of crown and root rot caused by *Rhizoctonia solani* AG-2-2 was observed in disease nurseries in either 1995 or 1996. Partial protection of plants against *Cercospora* leaf

spot was observed in experiments in MI in 1995, but this protection diminished when foliar sprays with the inducing chemicals were discontinued. Experiments in 1996 in MN and ND on control of *Cercospora* leaf spot produced mixed results: SAR-inducing chemicals proved partially effective at reducing leaf spot severity and increasing yields of a susceptible variety, but had little effect with a partially resistant variety at one of the locations. No significant effects were observed at a second location for either variety. Additional experiments on use of SAR for control of *Cercospora* are planned for both MI and ND in 1997.

## SOMATIC CELL SELECTION --Joseph W. Saunders

Somatic cell selection techniques used to produce sulfonylurea herbicide resistance in this lab in 1986 (1), and imidazolinone plus sulfonylurea resistance by Don Penner's weed science team here at Michigan State University in recent years (in preparation) have also been applied in efforts to obtain novel forms of disease resistance in sugarbeet.

Previous selection for resistance to the methionine analog ethionine had produced four resistant cell lines, one of which had regenerated shoots characterized by 8-10 fold greater tolerance to ethionine, small size, adventitious budding, and inability to develop roots. Inability to obtain rooted plants from this isolate could probably be overcome in the future by protoplast fusion with a normal regenerator genotype. Ethionine resistance would be expected to be recovered in the fusion hybrids because the original cell selection heavily favors recovery of dominant forms of resistance. Methionine in hydroponic solution provides protection against *Aphanomyces* in an indirect way (2). Soybean cell mutants resistant to ethionine have been reported, some of which overproduce methionine. Thus, ethionine resistance may confer some tolerance to *Aphanomyces*. This past year suspension cultures have been plated onto more than 2500 Petri dishes, with a total exposure to the ethionine by more than  $1.2 \times 10^6$  cell clusters of various sizes. One surviving callus has been recovered.

We've started work on the use of pectin lyase (PNL) from *Rhizoctonia solani* to select cells and identify plants resistant to the crown rot caused by that pathogen. Production of pectin lyase (PNL), one of the major enzymes involved in the pathogenesis of *Rhizoctonia solania* against sugarbeets, has been undertaken in the laboratory following the protocol established by Bugbee (3), with some modifications to improve efficiency and quantity of PNL produced. In contrast to Bugbee, we are currently culturing the *Rhizoctonia* in 150cm<sup>2</sup> tissue culture flasks (Corning, #430823) using 100 mL of the medium in each. The use of these flasks saves incubator space over the 5-6 week culture span. The production and storage of the enzyme has progressed to a point at which we currently have extracts which can soon be used for testing and cell selection.

At present, we have six different lines growing in the greenhouse that will be used for PNL testing. These diverse lines include three that are susceptible, and three that are resistant, to *Rhizoctonia*. These plants will be transferred to a controlled environment for acclimatization, to allow for more accurate and reproducible testing against PNL that was not a part of Bugbee's earlier research (3). PNL injection into petioles will be conducted, as per Bugbee, on these and later plants, to refine a screening procedure allowing selection of *Rhizoctonia* resistant plants at a seedling or juvenile stage.

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# EVALUATION OF SMOOTH ROOT AND BREEDING LINES OF SUGARBEET - 1996

**J.W. Saunders, J.M. McGrath and R.A. Kitchen**

USDA-Agricultural Research Service  
and Cooperative with  
Department of Crop and Soil Sciences

## CROP HISTORY

The 1996 sugarbeet field trials at the Bean and Beet Research Farm near Saginaw were planted in Range 5, Tiers 3 and 4. This land had been in wheat in 1995. The soil was prepared by fall plowing, followed by frost tillage in the early spring. Beets in experiments 961, 962, and 963 were planted on June 14, 1996. Pre-emergence herbicide (3 qt. Pyramin and 2 qt. Nortron SC per acre) was applied by Paul Horny, Farm Manager, immediately following seeding. All three experiments had good seed germination and good plant stands after thinning, and excellent chemical weed control. The plots were thinned to 8-10" between plants within the row and weeded the third week of July. Fertilizer at the standard recommended rate of 90 lbs. available N per acre was applied to the soil in tests 961, 962 and 963 in the fourth week of July, 1996 by side dressing between the rows. Experiments 961, 962 and 963 were machine harvested October 15-17, 1996.

## PROCEDURE

Tests 961, 962 and 963 included the commercial hybrid checks ACH 185 and Hilleshog Monohy E 17 and were planted in two row plots with rows 28" apart and 30 feet in length as 6-replicate trials. Warm weather in October and inoculation from a nearby field led to a severe and sudden outbreak of *Cercospora* leaf spot. Disease readings were obtained October 11, when it was considered too late to apply a controlling fungicide. The disease may have affected the agronomic performance of the more susceptible entries.

Just prior to harvest the length of each plot row was measured and adjustments made to correct for areas in the row where gaps were present and to determine the plot area. All roots were machine harvested for root weight and a fifteen beet sample from each plot was used for determining sucrose and clear juice purity (CJP) percentages. Sugar percentage and CJP percentages were determined by Michigan Sugar Company personnel in their research lab at Carrollton, MI using standard thin juice methods. A root smoothness score was estimated for each plot by observing the beets in the harvester weighing basket. Entries were scored on a 0-4 scale as defined below:

- 0 = Very smooth taproot, no grooves, broad fibrous root zone.
- 1 = Smooth, slightly grooved taproot, narrow fibrous root zone.
- 2 = Partially smooth, grooved, heavy fibrous non-branching taproot.
- 3 = Rough shaped taproot, deep grooves, heavy fibrous roots with some sprangling.
- 4 = Very rough, very deep grooves, multiple branched taproot.

Note that this scale has been shifted from a corresponding 1-5 scale in use prior to 1995. Data was analyzed using the Michigan State University MSTAT statistical program.

## **EXPERIMENTS 961, 962: AGRONOMIC RE-EVALUATION OF HIGH YIELD, SMOOTH ROOT DEVELOPMENTAL OR HIGH SUGAR PERCENTAGE PROGENIES FROM 1991 TO 1995.**

These experiments were designed to evaluate sucrose percentage and the agronomic performance of high sucrose smooth root (designated by HS in the number) progenies, smoothroot monogerm developmental lines (H designation) containing leafspot resistant EL50 germplasm, and high yield progenies produced by J. Clair Theurer in the five years prior to his retirement in 1995. The better performing lines with desirable smooth root or disease scores would be considered for release.

## **EXPERIMENT 963: AGRONOMIC EVALUATION OF HIGH SUGAR PERCENTAGE PROGENIES AND EXPERIMENTAL HYBRIDS.**

This experiment tested performance of prospective higher sugar smooth root releases 94JHS15 and 94JHS5 identified previously, as well as smooth root pollinator WC950377 and it's hybrids WC950378, WC950379 and WC950380 (produced on male sterile lines SP85657-01, SP85576-01 and FC607, respectively).

## **RESULTS**

Due to a very late planting date, sugar per acre totals were very low this year in these experiments. Sugar percentage of the high sugar check variety (ACH 185) was not significantly different from that of lines 95HS6, 95JHS15, 92HS33 and high sugar composite 91S3-00. Most H lines had sucrose percentages reflecting traditional (ie, fairly low) East Lansing program sucrose levels. All smooth root developmental lines tested here have SR scores above 1.5, meaning that they are only moderately smooth root. Interestingly, ACH 185 scored better for smoothroot in all three experiments (mean 2.08) than Monohy E 17 (2.35), significantly so in one.

Table 1: Sugar yield (RWSA and RWST), root yield in tons / acre (T/A), percent sucrose (Suc %), percent clear juice purity (CJP %), smooth root score (SR), and *Cercospora* leaf spot rating (LS) for experiment 961. B&B Farm, 1996.

Entry	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP %	*	SR	*	LS	*
ACH 185	4494	A	239.8	A	18.80	BCDE	17.11	A	92.71	ABC	1.96	CD	1.92	EF
93HS32-1	4136	AB	203.2	DEF	20.38	AB	15.03	CDE	91.64	CDEF	1.75	CDE	2.75	CD
E 17	4130	AB	230.4	B	17.90	BCDEF	16.30	B	93.26	A	2.38	A	3.33	BC
90H44	4116	AB	183.1	H	22.57	A	13.99	GH	90.56	FGH	2.29	AB	1.92	EF
93HS31	4112	AB	213.3	CD	19.26	BCD	15.51	C	92.24	ABCDE	1.67	DE	2.33	DE
92HS12	3880	BC	206.9	CDE	18.75	BCDE	15.24	CD	91.79	CDE	1.92	CDE	3.33	BC
92HS7-2	3836	BCD	199.1	EFG	19.30	BCD	15.20	CD	90.40	GH	1.83	CDE	2.67	CD
94HS21	3740	BCD	214.6	C	17.44	DEF	15.51	C	92.50	ABCD	1.58	E	3.17	C
94H1	3658	BCD	199.1	EFG	18.38	BCDEF	14.60	EF	92.09	BCDE	1.96	CD	1.33	F
90H40	3630	BCDE	178.9	H	20.30	ABC	13.54	H	91.09	EFGH	1.73	DE	2.17	DE
94H6	3620	BCDE	193.7	FG	18.69	BCDE	14.47	F	91.39	DEFG	2.00	BCD	1.83	EF
90H37	3434	CDEF	176.6	H	19.45	BCD	13.65	H	90.25	H	1.88	CDE	2.25	DE
94HS18	3401	CDEF	210.5	CD	16.17	EFG	15.31	CD	92.32	ABCD	1.58	E	3.83	AB
94H4	3380	CDEF	193.0	G	17.53	CDEF	14.23	FG	91.97	BCDE	1.88	CDE	1.92	EF
92HS10	3261	DEF	207.9	CDE	15.68	FG	15.38	CD	91.55	CDEF	2.08	ABC	4.25	A
94HS22	3260	DEF	205.9	CDE	15.79	FG	14.94	DE	92.47	ABCD	1.67	DE	3.00	C
91B16	3048	EF	212.3	CD	14.39	GH	15.41	CD	92.36	ABCD	2.33	A	2.25	DE
93HS30	2931	F	231.5	AB	12.59	H	16.46	B	93.01	AB	1.83	CDE	4.42	A
Mean	3624		204.2		17.64		15.10		91.86		1.88		2.45	

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level. Bold indicates best score.



Table 2: Sugar yield (RWSA and RWST), root yield in tons / acre (T/A), percent sucrose (Suc %), percent clear juice purity (CJP %), smooth root score (SR), and *Cercospora* leaf spot rating (LS) for experiment 962. B&B Farm, 1996.

Entry	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP %	*	SR	*	LS	*
95HS6	4303	A	234.8	A	18.32	A	16.50	A	93.54	A	1.54	D	3.08	E
ACH 185	4007	AB	232.9	AB	17.19	AB	16.48	AB	93.23	AB	2.04	AB	3.17	DE
95H6	3780	BC	206.7	E	18.37	A	15.05	E	92.30	C	1.83	BC	2.42	F
E 17	3768	BC	232.1	ABC	16.28	ABC	16.48	AB	93.06	ABC	2.21	A	4.00	BC
92HS33	3680	BC	222.9	BCD	16.52	ABC	15.98	ABC	92.74	ABC	1.75	CD	4.33	B
95HS2	3622	BC	214.9	DE	16.86	ABC	15.38	DE	92.96	ABC	1.71	CD	2.17	F
92HS15	3593	BC	221.9	CD	16.25	ABC	15.91	C	92.75	ABC	1.63	CD	3.67	CD
91S3-00	3460	BCD	225.5	ABC	15.35	BCD	16.21	ABC	92.59	BC	2.25	A	4.25	BC
95HS18	3328	CDE	226.4	ABC	14.71	CD	15.96	BC	93.49	AB	1.58	CD	4.00	BC
93HS27	3041	DE	222.8	BCD	13.68	D	15.85	CD	93.10	ABC	1.75	CD	5.00	A
93HS35-8	2898	E	209.6	E	13.85	D	15.24	E	92.31	C	1.58	CD	5.50	A
Mean	3547		222.4		15.98		15.90		92.91		1.78		3.5	

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level.

Table 3: Sugar yield (RWSA and RWST), root yield in tons / acre (T/A), percent sucrose (Suc %), percent clear juice purity (CJP %), smooth root score (SR), and *Cercospora* leaf spot rating (LS) for experiment 963. B&B Farm, 1996

	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP %	*	SR	*	LS	*
ACH 185	4691	A	237.3	A	19.76	AB	16.91	A	92.83	AB	2.25	B	2.0	C
E 17	4357	AB	230.5	AB	18.95	BC	16.40	AB	93.00	A	2.46	AB	3.5	AB
WC950378	4022	BC	190.4	C	21.17	A	14.27	C	91.30	DE	1.67	D	2.8	B
96JHS15	3746	CD	224.0	B	16.75	D	16.36	AB	91.88	BCD	1.79	CD	3.3	AB
WC950379	3671	CDE	201.0	C	18.22	BCD	14.74	C	92.09	ABCD	1.92	C	3.1	AB
WC950380	3655	CDE	195.9	C	18.71	BCD	14.31	C	92.32	ABC	1.75	CD	3.0	AB
96RR	3549	DEF	187.3	C	18.98	BC	14.22	C	90.79	E	2.58	A	1.3	D
WC950377	3264	EF	191.4	C	17.08	CD	14.26	C	91.53	CDE	1.58	D	3.1	AB
96JHS5	3167	F	220.3	B	14.36	E	15.77	B	92.87	AB	1.75	CD	3.7	A
Mean	3737		207.1		18.02		15.18		92.06		1.92		2.6	

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level. Bold indicates best score.

# **EVALUATION OF SOMACLONAL AND FIELD SELECTION LINES FOR NITROGEN USE RESPONSE - 1996**

**J.W. Saunders, J.M. McGrath and R.A. Kitchen**

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Department of Crop and Soil Sciences

Nitrogen fertilization is a critical component of growing a good sugarbeet crop. Sufficient N is required for rapid early growth and quick development of a full canopy of leaves for maximum photosynthesis, plant growth, and sucrose accumulation. Excess N at harvest results in higher impurities in the root and less efficiency in processing to sugar. Additionally, there is growing concern about the quantity of nitrogenous chemicals in natural bodies of water. In 1990 a research program was initiated to evaluate diverse genotypes for their potential difference in tolerance to high N or their efficiency for high sugar production with low nitrogen availability. Minor differences in N response were noted for some genotypes in past years. In 1996 we continued research on nitrogen and genotypes by evaluating the response of several somaclonal hybrids as well as several amino-N level selection populations to differential nitrogen fertilization treatments.

## **EXPERIMENT 964: EVALUATION OF SOMACLONE HYBRIDS FROM CELL SELECTION FOR NITROGEN USE RESPONSE.**

For experiment 964, somaclonal hybrids were created from the cytoplasmic male sterile regenerable clone 8266-10. The standard procedure for producing regenerate plants was followed: young incompletely expanded leaves were surface disinfected, 8 mm discs cut from them and placed singly on nutrient agar in Petri plates, and the plates sealed with parafilm. Plates were incubated at 30 C in the dark, and after a month callus appeared. After another month, shoots regenerating on the callus were pulled out individually, labeled as individual somaclones, and multiplied. Shoots were rooted in vitro on an NAA medium and established as plants in the greenhouse. After growth in the greenhouse to increase root size and thus seed production potential, the male sterile somaclones and ramets of the source plant 8266-10 were vernalized and crossed in parallel in a common crossing block with multigerm pollinator line SR-93.

In the shoot multiplication and rooting steps of this process, standard Murashige-Skoog medium was used, with its nitrate-ammonium mix totaling 60 mm. However, the callus induction step was conducted not with the inorganic nitrogen forms (nitrate and ammonium) but with 30 mm glutamine as the sole nitrogen source.

Somaclones are regenerate plants from an original individual whose plant parts, leaves in this case, gave rise to callus and subsequent shoots. Most somaclones visually resemble the source plant, and behave physiologically very like that source plant. However, it is well known that passage through the callus phase results in a fairly high rate of mutation in cells that can be manifested in various degrees at the cell and whole plant level. Mutations of various magnitudes can affect nutrition. There were two alternatives or selection schemes planned in our original premise to search for genotypes with greater nitrogen use efficiency: 1) genotypes that could metabolize an excess of nitrogen fertilizer without decreasing the sucrose content or increasing

the amino N and other impurities in the sugarbeet root at harvest; and 2) genotypes that could produce a satisfactory root and sugar yield with a limited quantity of nitrogen. and metabolism in the callus cells themselves, and affect fitness of these cells and relative cell division rate. Mutations improving cell fitness in callus growth would be reflected in disproportionate increase in number of cells carrying the mutation. This should be reflected in increased proportions in the population of regenerate shoots.

This quantitative selection at the cell level merely increases the probability of a mutant plant with a significant alteration of nitrogen use efficiency or accumulation pattern of nitrogenous impurities, with the increase of probability being generally proportional to the increase in fitness that the mutation imparts. Use of glutamine as sole nitrogen source creates a quantitative selective regime at the cell level for more efficient flow through of nitrogen via this key intermediate of nitrogen metabolism.

Because producing enough  $S_1$  seed on somaclone ramets of sugarbeets is impractical,  $F_1$  seed was chosen as the way to evaluate progeny for altered field performance. 96JN1 was the check hybrid produced on the source clone 8266-10, whereas 96JN2 through 7 were somaclonal hybrids each meant to be compared directly with 96JN1 by t test (Table 4-1).

#### **EXPERIMENT 965: EVALUATION OF FIELD SELECTION LINES FOR NITROGEN USE EFFICIENCY.**

Two high sucrose percentage source populations, (WC91270M and 93S1-00) were included in the experiment, as were seven and two second generation selection lines from them respectively. The commercial check ACH185 was included as a general reference entry. Both selection lines from 93S1-00 were produced from increases of original seed from a single cycle of selection for high sucrose % and low amino-N of beets grown under standard (i.e., 90# per acre) nitrogen rates. Each original line was a pair cross made by crossing two beets which had been half-rooted for sucrose and amino-N determinations. All selection lines from WC91270M were produced by increases of original seed from a single cycle of selection as described for 93S1-00. Three of the seven original selection lines from WC91270M were produced as with 93S1-00, three more involved pair crosses of half-roots selected for high sucrose % and high amino-N, and the seventh line (95N16) was an intercrossing of ten half-rooted beets high in sucrose % and low in amino-N (Table 5-1). All experimental seed were increases of seed tested on the Saginaw Valley farm in the 1995 nitrogen response experiments, and have 96 seed numbers corresponding exactly with the 95 seed numbers. 96N14 and 96N15 were meant to be compared directly to their source population 93S1-00, whereas the remaining seven 96N entries are meant to be compared directly with WC91270M.

#### **PROCEDURE**

The total of ten entries for test 964 and twelve for test 965 were planted in randomized block factorial design of four replications split for nitrogen levels (0, 60, 120 #/A for test 964; 60, 120 #/A for test 965). Individual plots were single rows because of limited seed quantities, but were of standard length and width spacing, i.e., 28" apart and 30' in length.

Tests 964 and 965 were planted in Range 5, Tiers 3 and 4. This land had been in wheat in 1995. The soil was prepared by fall plowing, followed by frost tillage in the early spring. Beets were

planted on June 14, 1996. Pre-emergence herbicide (3 qt. Pyramin and 2 qt. Nortron SC) was applied by Paul Horny, Farm Manager, immediately following seeding. Both experiments had good seed germination and chemical weed control. The plots were thinned to 8-10" between plants within the row and weeded the third week of July. Experiment 964 was given differential nitrogen fertilizer treatments by side dressing the thirds of each rep with 0, 60 or 120# N/acre ammonium nitrate in accordance with the split plot field design. Experiment 965 received 60 or 120 #N/A ammonium nitrate according to the field design. The field was cultivated once prior to layby. Experiments 964 and 965 were machine harvested October 17-18, 1996. The length of each plot was measured just prior to harvest to adjust plot size for any gaps within the rows. All roots were harvested in each plot and were weighed to determine root yield and RWSA. A fifteen beet random sample of roots was taken from each plot to determine sucrose percentage, CJP percentage and meq amino N per 100 g. sugar. These determinations were made by Michigan Sugar Company personnel at their research lab in Carrollton, MI. Data was summarized and analyzed using the MSTAT statistical program developed at Michigan State University.

## RESULTS

**EXPERIMENT 964:** Plant stand for all entries was good. Means of nitrogen application levels summed over entries for sugar yield, root yield, sucrose percent, CJP, and meq. amino N/100 grams of sugar are given in Table 4-2. In this test, all agronomic parameters save RWSA responded to progressively higher nitrogen fertilization levels as expected from most previous nitrogen level experiments industry-wide: tonnage per acre increased whereas the quality parameters recoverable white sugar per ton, sucrose percentage, clear juice purity percentage and amino nitrogen decreased (Table 4-2).

Means of entries summed over nitrogen levels show no significant differences for all characteristics measured between and among the somaclonal hybrids and the appropriate comparable check hybrid (96JN1) made using the source clone for the somaclones (Table 4-3). Individual performance means for entries at each nitrogen level are given in Table 4-4. All t-test comparisons of each somaclone performance mean relative to the genetically comparable control (96JN1) at each nitrogen level were non-significant. There were no interactions between entry and nitrogen level. As a group, the three commercial hybrids distinguished themselves from the somaclonal group in all but tonnage. They had been included in the experiment for general reference.

**EXPERIMENT 965:** Plant stand for all entries was good. Means for agronomic parameters for the two nitrogen application levels summed over entries were consistent with conventional expectations for RWST, T/A, suc%, CJP% and amino N, although statistical significance was only achieved for the amino N parameter (Table 5-2).

The ACH 185 commercial variety reference check had the significantly highest RWSA, whereas 93S1-00, one of the pre-selection source populations, had the lowest RWSA, less than 50% of the commercial check RWSA value (Table 5-3). One appropriate set of comparisons between source population and two selection lines shows 93S1-00 with significantly less tonnage than both derivative lines (96N14, 96N15), significantly more sucrose than one of the lines, and significantly less CJP and more amino N than the two derivative lines. 96N14 was significantly better for tonnage and amino N, but significantly worse for sugar % and CJP. The other

appropriate set of comparisons involves WC91270M (L19/2) and the remaining seven derivative lines. 96N16 had significantly higher tonnage. No line had significantly higher sucrose %. No line had significantly higher CJP than the source, although two lines had significantly lower. Likewise, no derivative line had lower (i.e., better) amino N than the source, but one had worse.

Individual performance means for entries at each nitrogen level are given in Table 5-4, as are the t-tests comparing the performance of each derivative with that of its source. Differences in significance for agronomic parameters for any entry between levels of nitrogen applied may indicate interactions for response to nitrogen.

## DISCUSSION

Experiment 964 evaluated six somaclonal hybrids corresponding to six somaclones, originating on the key metabolic intermediate glutamine, for differences in agronomic performance and response to nitrogen, the latter measured by differential response to nitrogen fertilization. There were no significant differences in agronomic performance, suggesting no significant genetic changes affecting agronomic performance. Because of the outcrossing involved in making the hybrids for evaluation, genetic changes of a recessive nature in the somaclone, whatever their magnitude, would not have been detected or selected.

Two mechanisms for recovery of somaclonal variants with detectable differences in agronomic performance and nitrogen response are recognized: quantitative cell selection based on improved cell fitness, and random mutation in the callus. These have considerably low probabilities, relative to, say, qualitative cell selection previously encountered with herbicide resistant somaclonal variants. An additional factor that could have interfered with recovery of some somaclonal variants would be any lack of correspondence between cellular and whole plant behavior. Enough seed to test in a nitrogen experiment was only produced by the six entries included in experiment 964. With low selection efficiency likely in quantitative cell selection, larger numbers of entries with larger seed quantities are needed if this approach is to pay off.

Experiment 965 evaluated lines derived from respective pair crosses of selected high sugar percentage beets, with either high or low amino N, from two high sugar source lines. This was a repeat of sorts of an experiment conducted in 1995 at the B & B farm, using the next generation of seed from simple increases.

Of the nine selection lines only one (96N14) performed significantly better in any category, tonnage and amino N in its case. 96N7 performed insignificantly better than its source for sugar %, CJP and amino N. 96N12, the increase of last year's best prospect, was largely indistinguishable from its source population in 1996. Overall, direction of selection (i.e., low vs. high amino-N) did not display an effect, although this was not tested statistically. There were no interactions between entry and nitrogen level.

Overall, significant improvements in agronomic performance have been achieved only with the N14 selection line ('95 as well as '96 seed generations), starting with a source population of low tonnage characteristics. It is fitting to mention parts of last year's discussion where the need to start with more selected beets in each line was noted, as well as the importance of maximizing seed production in each generation to permit greater replication in the experiments, thus allowing

more power to detect significant differences.

Table 4-2: Means for N level summed across varieties for sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g sugar. Experiment 964. B&B Farm, 1996.

Level # N/A	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP%	*	Amino	*
											N % S	
0	4156	A	232.6	A	17.9	B	16.3	A	93.6	A	13.6	C
60	4248	A	225.0	B	19.0	A	16.1	A	92.7	B	16.2	B
120	4130	A	208.8	C	19.8	A	15.3	B	92.0	C	21.7	A
Mean	4177		222.1		18.7		15.9		92.8		17.2	

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level

Table 4-3: Means for varieties summed across N levels, sugar yield, root yield, sucrose percentage, clear juice purity percentage and meq amino N/100 g sugar for sugarbeet genotypes grown under three N environments. Experiment 964. B&B Farm, 1996.

Entry	RWS	*	RWS	*	T/A	*	Suc %	*	CJP%	*	Amino	*
	A		T								N % S	
ACH 185	5108	A	261	A	19.6	A	18.2	A	93.5	ABC	13.2	BC
E 17	4449	BC	247	B	18.1	A	17.1	B	93.9	A	13.5	BC
BETA 5931	4793	AB	254	AB	19.0	A	17.7	AB	93.7	AB	11.8	C
96JN1	3890	D	209	C	18.6	A	15.2	C	92.4	BCD	19.2	A
96JN2	3666	D	207	C	17.8	A	15.0	C	92.4	BCD	19.3	A
96JN3	4055	CD	208	C	19.6	A	15.1	C	92.3	CD	17.3	AB
96JN4	4043	CD	207	C	19.6	A	15.1	C	92.4	BCD	19.7	A
96JN5	4093	CD	210	C	19.6	A	15.2	C	92.4	BCD	19.9	A
96JN6	3840	D	207	C	18.6	A	15.1	C	92.0	D	18.5	AB
96JN7	3844	D	212	C	18.2	A	15.2	C	92.9	ABCD	19.3	A
Mean	4177		222		18.9		15.9		92.8		17.2	

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level. Bold indicates best score.

Table 4-4: Sugar yield, root yield, sucrose percentage, clear juice purity percentage and meq amino N/100 g sugar for sugarbeet genotypes grown under three N environments. Experiment 964. B&B Farm,1996.

Entry	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP%	*	Amino N % S	*	Level #N/A
ACH 185	5143	A	269.6	A	19.1	ABCDE	18.6	A	94.1	AB	8.9	J	0
	4899	ABC	265.5	AB	18.5	ABCDEF	18.5	A	93.5	ABC	12.8	GHUJ	60
	5283	A	248.6	DE	21.3	A	17.6	BC	93.1	ABCDEF	17.9	CDEFG	120
E17	4400	DEFG	253.8	AB	17.3	DEF	17.4	BCD	94.4	A	10.7	HIJ	0
	4589	BCDE	250.2	CDE	18.4	BCDEF	17.3	BCD	94.1	AB	12.2	GHUJ	60
	4357	DEFG	239.9	EF	18.5	BCDEF	16.7	E	93.3	ABCDE	17.5	CDEFG	120
BETA 5931	4490	CDEF	262.8	ABC	17.1	EF	18.0	AB	94.3	A	10.0	IJ	0
	5061	AB	258.1	ABCD	19.7	ABCDE	18.0	AB	93.4	ABCD	10.8	HIJ	60
	4828	ABCD	239.9	EF	20.1	ABCD	16.9	DE	93.2	ABCDE	14.7	EFGHIJ	120
96JN1	3939	GHUJ	221.1	HI	17.8	CDEF	15.7	FG	93.1	ABCDEF	14.5	EFGHIJ	0
	3924	GHUJ	212.8	I	18.5	ABCDE	15.5	FG	92.3	CDEFGH	19.0	BCDEF	60
	3807	HIJ	193.7	K	19.6	ABCDE	14.3	I	92.0	EFGH	24.1	AB	120
96JN2	3508	J	217.6	HI	16.1	F	15.4	FG	93.6	ABC	16.0	DEFGHI	0
	3911	GHUJ	210.3	I	18.6	ABCDEF	15.3	FGH	92.3	CDEFGH	16.4	DEFGH	60
	3579	IJ	192.9	K	18.5	ABCDEF	14.4	I	91.3	H	25.6	A	120
96JN3	4045	FghiJ	220.3	HI	18.4	BCDEF	15.6	FG	93.5	ABC	13.8	FghiJ	0
	4106	EFGHI	210.6	I	19.5	ABCDE	15.4	FG	92.0	DEFGH	14.8	EFGHIJ	60
	4012	FghiJ	193.6	K	20.8	AB	14.5	I	91.2	H	23.5	ABC	120
96JN4	3989	FghiJ	218.6	HI	18.3	BCDEF	15.6	FG	93.2	ABCDEF	14.9	EFGHIJ	0
	4168	EFGH	207.4	IJ	20.2	ABC	15.2	GH	92.0	DEFGH	18.2	BCDEFG	60
	3970	FghiJ	195.9	JK	20.3	ABC	14.4	I	91.9	EFGH	25.9	A	120
96JN5	4111	EFGHI	218.9	HI	18.8	ABCDEF	15.6	FG	93.1	ABCDEF	16.6	DEFGH	0
	4155	EFGH	215.5	HI	19.3	ABCDE	15.5	FG	92.7	BCDEFG	20.3	ABCDE	60
	4011	FghiJ	194.8	JK	20.6	ABC	14.6	I	91.3	GH	22.7	ABC	120
96JN6	3888	GHUJ	216.1	HI	18.0	BCDEF	15.5	FG	92.7	BCDEFG	15.8	DEFGHI	0
	3860	GHUJ	208.2	IJ	18.6	ABCDEF	15.2	FGH	92.1	DEFGH	18.1	BCDEFG	60
	3770	HIJ	196.2	JK	19.2	ABCDE	14.7	HI	91.3	H	21.7	ABCD	120
96JN7	4047	FghiJ	227.4	GH	17.8	CDEF	15.9	F	93.9	AB	15.1	EFGHI	0
	3805	HIJ	211.7	I	18.0	BCDEF	15.2	FGH	92.8	BCDEF	19.4	BCDEF	60
	3680	HIJ	195.9	JK	18.8	ABCDEF	14.5	I	91.8	FGH	23.4	ABC	120

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level. Bold indicates best score. Note t-test were not significant at 0/05 level.



Table 5-1. Description of genotypes used in somaclonal nitrogen use efficiency study. B&B Farm, 1996.

Genotype	Description
ACH 185	Commercial Hybrid
WC91270M	L19/2
93S1-00	L19-C51 F4
96N14	Increase of L19-C51 F4, High Sugar, Low amino N selection
96N7	Increase of L19/2, High Sugar, Low amino N selection
96N8	Increase of L19/2, High Sugar, Low amino N selection
96N9	Increase of L19/2, High Sugar, Low amino N selection
96N10	Increase of L19/2, High Sugar, High amino N selection
96N12	Increase of L19/2, High Sugar, High amino N selection
96N13	Increase of L19/2, High Sugar, High amino N selection
96N16	Increase of L19/2, High Sugar, Low amino N selection
96N15	Increase of L19-C51 F4, High Sugar, Low amino N selection

Table 5-2: Means for N level summed across varieties for sugar yield, root yield, sucrose percentage, clear juice purity percentage, and meq amino N/100 g sugar. Experiment 965. B&B Farm, 1996.

Level # N/A	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP%	*	Amino N % S	*
60	3529	A	236.8	A	14.8	A	17	A	92.5	A	19.4	A
120	3457	A	231.5	A	14.9	A	16.8	A	92.2	A	22.4	B
mean	3493		234		14.9		16.9		92.4		20.9	

\* T-test: Means with same letter are not significantly different at the 0.05 level

Table 5-3: Means for varieties summed across N levels, sugar yield, root yield, sucrose percentage, percentage, clear juice purity percentage and meq amino N/100 g sugar for sugarbeet genotypes grown under three N environments. Experiment 965. B&B Farm, 1996.

Entry	RWSA	*	RWST	*	T/A	*	Suc %	*	CJP%	*	Amino N % S	*
ACH 185	4914	A	251	AB	19.6	A	17.8	AB	93.0	A	16.6	E
WC91270M	3759	BC	243	BC	15.5	C	17.4	ABC	92.4	AB	19.9	CDE
93S1-00	2330	E	224	E	10.4	E	16.6	DE	91.3	C	24.7	AB
96N14	3585	C	213	F	16.8	B	15.2	F	93.1	A	20.3	CD
96N7	3834	BC	254	A	15.1	C	18.0	A	93.0	A	17.2	DE
96N8	3495	C	244	BC	14.4	C	17.3	ABC	92.9	A	21.2	C
96N9	3514	C	228	DE	15.5	C	16.8	CDE	91.4	C	24.9	AB
96N10	2673	DE	222	EF	12.0	D	16.3	E	91.8	BC	21.8	BC
96N12	3463	C	239	C	14.5	C	17.2	BCD	92.5	AB	19.9	CDE
96N13	2752	D	220	EF	12.5	D	16.2	E	91.4	C	25.2	A
96N16	4009	B	236	CD	17.0	B	16.8	CDE	92.7	A	19.4	CDE
96N15	3599	C	239	C	15.2	C	17.0	CD	92.7	A	20.0	CDE
Mean	3368		233.5		14.5		16.9		92.3		20.6	

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level. Bold indicates best score.

Table 5-4: Sugar yield, root yield, sucrose percentage, clear juice purity percentage and meq amino N/100 g sugar for sugarbeet genotypes grown under three N environments. Experiment 965. B&B Farm, 1996.

Entry	RWSA	*	RWST		T/A		Suc %		CJP%		Amino		t-test	Level
			t-test	*	t-test	*	t-test	*	t-test	*	N	S		
ACH 185	4945	A	253.5	AB	20	A	17.8	AB	93.2	AB	16.0	G		60
	4883	A	248.6	ABCD	20	A	17.7	ABC	92.8	ABCDE	17.1	FG		120
WC91270M	3801	BCD	242.5	BCDEF	16	BCDE	17.4	ABCDE	92.4	ABCDEFG	20.3	CDEFG		60
	3717	BCD	242.4	BCDEF	15	BCDE	17.5	ABCDE	92.3	ABCDEFG	19.4	DEFG		120
93S1	2258	F	222.2	HJK	10	J	16.6	EFGH	90.9	H	23.3	ABCDE		60
	2402	EF	225.5	GHIJK	11	IJ	16.6	EFGH	91.6	FGH	26.2	AB		120
96N14	3756	BCD	220.5	JK	17	B	15.6	I	93.3	AB	19.1	DEFG	**	60
	3415	D	204.7	L	17	BCD	14.7	J	92.9	ABC	21.5	BCDEF	ns	120
96N7	3973	BC	257.1	A	16	BCDE	18.1	A	93.0	ABC	15.6	G	*	60
	3695	BCD	251.1	AB	15	CDEF	17.8	AB	92.9	ABC	18.8	DEFG	ns	120
96N8	3524	BCD	250.2	ABC	14	EFG	17.5	ABCD	93.5	A	17.0	FG	ns	60
	3467	CD	237.3	CDEFG	15	DEF	17.1	BCDEFG	92.4	ABCDEFG	25.4	ABC	ns	120
96N9	3613	BCD	230.8	FGHIJ	16	BCDE	16.9	CDEFGH	91.8	DEFGH	22.8	ABCDE	ns	60
	3414	D	224.4	GHIJK	15	BCDE	16.7	DEFGH	91.0	H	27.0	A	*	120
96N10	2765	EF	223.8	HJK	12	GHI	16.3	GHI	91.9	CDEFGH	19.6	DEFG	ns	60
	2582	EF	220.9	IJK	12	HIJ	16.2	GHI	91.7	EFGH	24.0	ABCD	ns	120
96N12	3507	BCD	245.1	ABCDE	14	EF	17.5	ABCD	92.6	ABCDEFG	19.8	DEFG	ns	60
	3419	D	233.1	EFGHIJ	15	DEF	16.8	CDEFGH	92.3	BCDEFG	20.1	CDEFG	ns	120
96N13	2598	EF	216.0	K	12.0	HIJ	16.0	HI	91.4	GH	23.0	ABCDE	ns	60
	2907	E	223.0	HJK	13.0	FGH	16.5	FGH	91.4	GH	27.5	A	*	120
96N16	3978	BC	236.9	DEFG	17	BC	16.9	CDEFGH	92.9	ABCD	18.5	EFG	ns	60
	4041	B	234.0	EFGHI	17	B	16.8	DEFGH	92.6	ABCDEFG	20.4	CDEFG	ns	120
96N15	3629	BCD	243.5	BCDEF	15	CDEF	17.4	ABCDEFG	92.8	ABCDE	18.4	EFG	**	60
	3583	BCD	234.3	EFGH	16	BCDE	16.8	DEFGH	92.7	ABCDEFG	21.5	BCDEF	ns	120

\* Duncan's Multiple Range test: Means with same letter suffix are not significantly different at the 0.05 level. Bold indicates best score. T-test: ns (not significant), \* and \*\* (significant at 0.05 and 0.01 level, respectively).

**PRODUCTION OF DIHYDROXY PHENOLIC PHYTOALEXINS BY SUGARBEETS IN  
RESPONSE TO CHALLENGE BY *RHIZOCTONIA SOLANI***

D. J. Johnson and J. M. Halloin

*BSDF Project 720*

Attempts continued to isolate and characterize the phenolic phytoalexins localized in tissues immediately surrounding disease lesions caused by *Rhizoctonia solani*. These compounds react to form red-colored nitroso derivatives, demonstrating that they are o-dihydroxy phenolics. Present and previous attempts to isolate and characterize these phytoalexins have been unsuccessful. We suspect that the compounds involved are highly reactive quinones of the phenolic compounds.

The phenolics dopa and dopamine have been shown to be constituents of sugarbeet leaves, and have been implicated in expression of resistance to *Cercospora* leaf spot. These compounds are o-dihydroxy phenolics, form red-colored nitroso derivatives, and are likely the source of nitroso staining that we previously reported in sugarbeet petioles. The absence of noticeable staining in healthy tap roots indicates that they are absent or in very low concentrations in tap roots. They may, however, be produced in association with the healing response around *R. solani* lesions. Experiments demonstrated high activities of polyphenol oxidase in tissues around healing disease lesions. Dopa and dopamine were excellent substrates for this enzyme.

Attempts to isolate germplasms unusually high or low in production of the phytoalexins are continuing.

**EVALUATION OF RESISTANCE OF SUGARBEETS TO APHANOMYCES SEEDLING DISEASE: CONDITIONS AFFECTING DISEASE SEVERITY IN A MODEL SYSTEM.**

J. M. Halloin, D. J. Johnson, D. A. Ganoff, and A. H. Lammers.

*BSDF Project 721*

*Aphanomyces cochlioides* causes damping-off of sugarbeet seedlings throughout U.S production areas. We present a method for uniform production and inoculation of seedlings and evaluation of disease severity. Seeds of a susceptible variety were placed on moist germination papers which were then folded and rolled to form cylindrical "rag dolls"; these were kept under constant light at 22°C for 4 days. Seedlings longer than 5 cm were transferred in groups of 25 to water (controls) or to suspensions of *A. cochlioides* zoospores and incubated for 10 minutes. They were placed in new rag dolls, incubated in growth chambers at 15, 20, 25, or 30°C for 5 days under constant light, and were evaluated for disease development 1, 3, and 5 days after inoculation. Disease severity was rated on a scale of 0 to 4 (0 = no disease, 1 = 1 to 25%, and 4 = >75% of tissue rotted). Inoculated seedlings incubated at 30°C had mean ratings of ca. 4 after 3 days, whereas seedlings at 15°C were moderately diseased (mean score ca. 2) after 5 days. The rate of disease development was intermediate at 20 and 25°C. Occasional symptoms observed on control seedlings usually were attributable to breakage during handling. These methods provide a useful means for assessment of disease development in large populations of seedlings. Future experiments will use these methods to discriminate between resistant and susceptible varieties and to select resistant individuals for breeding purposes.

# **RHIZOCTONIA CROWN AND ROOT ROT EVALUATION FOR COMMERCIAL SUGARBEET HYBRIDS AT EAST LANSING, MI, 1996**

J. M. Halloin and L. Hubble

The 1996 Rhizoctonia commercial test included 24 entries, with four replications. Two rates of inoculum were used (the normal rate, and 1/3 the normal rate) to determine if disease severity could be better controlled by changing amount of inoculum. Plants were scored on a scale of 0 to 4, with 0 = no lesions found, 1 = up to 25% of the root covered with lesions, and 4 = 76 to 100% of the root covered with lesions. Dead or missing plants were scored as 4.

Entry number 24, the resistant check, failed to emerge and was thus excluded from the analysis and the results reported below. The susceptible check was Univers.

There was essentially no difference as a result of amount of inoculum used, although there were occasional differences in the overall ranking of entries. A few of the entries appear to have resistances to Rhizoctonia that range from better than most, to very good.

Table 1. Disease ratings of sugarbeet entries in the commercial Rhizoctonia crown and root rot test at East Lansing, MI, 1996.

Variety	Score (1X)	Score (1/3X)	Combined
ACH 555	3.19 A	2.45 ABC	2.82
BETA 4546	2.91 AB	2.56 ABC	2.73
E-10	2.85 ABC	2.22 BC	2.54
ACH 185	2.85 ABC	2.11 BC	2.48
BETA 5603	2.80 ABC	2.82 AB	2.81
BETA 5335	2.74 ABCD	2.61 ABC	2.68
ACH 510	2.73 ABCD	3.05 A	2.89
E-4	2.72 ABCD	2.49 ABC	2.61
ACH 503	2.68 ABCD	2.82 AB	2.75
BETA 5344	2.67 ABCD	2.37 ABC	2.52
BETA 5713	2.55 ABCD	2.33 ABC	2.44
BETA 5585	2.55 ABCD	2.29 ABC	2.42
BETA 5931	2.55 ABCD	2.70 AB	2.62
E-17	2.46 ABCD	2.36 ABC	2.41
UNIVERS	2.45 ABCD	2.65 AB	2.55
E-9	2.45 ABCD	2.30 ABC	2.37
ACH 197	2.43 ABCD	2.31 ABC	2.37
BETA 5823	2.40 ABCD	2.27 BC	2.34
ACH 308	2.20 ABCDE	2.24 BC	2.22
HM 2725	1.94 BCDE	1.85 CD	1.90
SX 1214	1.87 CDE	2.51 ABC	2.19
ACH 1353	1.80 DE	1.40 D	1.60
HM RH3	1.36 E	1.29 D	1.32
L.S.D. (0.05)	0.81	0.64	-
MEANS	2.49	2.35	2.42

# USE OF INDUCED HOST RESISTANCE FOR CONTROL OF SUGARBEET DISEASES.

J. M. Halloin, A. W. Cattanach, and G. A. Smith

Induced host resistance, disease resistance induced by prior infections or by chemicals that are themselves non toxic, has been demonstrated in numerous crops. Previously (these reports, 1995) experiments at East Lansing, MI on use of induced resistance for control of seedling diseases, crown and root rot caused by *Rhizoctonia solani*, and leaf spot caused by *Cercospora beticola*. Only experiments on control of leaf spot were successful. In 1996 experiments were done in MN and ND on control of *Cercospora* leaf spot. The experiments at East Lansing, MI, were unsuccessful, due to failure to establish infection by the fungus. The experiments in ND produced mixed results: the resistance-inducing chemical Actigard proved partially effective at reducing leaf spot severity and increasing yields of a susceptible variety, but had little effect with a partially resistant variety at one of the locations. No significant effects were observed at a second location for either variety. Additional experiments on use of induced resistance for control of *Cercospora* are planned for both MI and ND in 1997.

Table 1. The effect of the resistance inducer Actigard and TPTH + Penncozeb on severity of *Cercospora* leaf spot at Wahpeton, ND (1996).

Treatment	Variety	CLS Rating			Yield (T/A)
		8/13	9/4	9/20	
Check	B 5639 (res.)	1.1	1.9	2.6	19.9
Actigard		1.1	1.9	2.4	18.4
TPTH + Pen		1.0	1.4	2.3	20.7
Actigard + TPTH + Pen		1.0	1.4	2.0	19.6
Check	V 6140 (sus.)	2.4	5.1	6.8	20.6
Actigard		2.4	3.4	5.3	22.5
TPTH + Pen		1.5	1.9	2.3	24.9
Actigard + TPTH + Pen		1.5	2.0	2.5	25.4
L.S.D. (0.05)		0.1	0.6	0.7	1.9

Table 2. The effect of the resistance inducer Actigard and TPTH + Penncozeb on severity of Cercospora leaf spot at Fargo, ND (1996).

Treatment	Variety	CLS Rating			Yield (T/A)
		8/12	9/4	9/25	
Check	B 5639	1.6	1.8	2.4	14.7
Actigard	(res.)	1.4	1.7	2.1	13.8
TPTH + Pen		1.1	1.7	2.1	14.7
Actigard + TPTH + Pen		1.2	1.5	2.0	16.4
Check	V 6140	2.5	2.6	4.1	16.2
Actigard	(sus.)	2.3	2.4	4.0	17.7
TPTH + Pen		1.4	2.1	2.3	18.3
Actigard + TPTH + Pen		1.3	1.8	2.3	18.0
L.S.D. (0.05)		0.2	0.6	1.2	2.8

# **SUGARBEET RESEARCH**

## **1996 Report**

### **Section F**

**Texas Agricultural Experiment Station  
Bushland, Texas**

**Dr. C. M. Rush**

**Cooperation:**

**Holly Sugar Corporation - Sugarland, Texas  
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Foundation (Project 503)**





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**HARVESON, R.M., C.M. RUSH, and T.A. WHEELER. 1996. The spread of beet necrotic yellow vein virus from point source inoculations as influenced by irrigation and tillage.** *Phytopathology*, 86:1242-1247.

A 3-year study was initiated in 1992 to map the spread of beet necrotic yellow vein virus (BNYVV) from known point sources of inoculum by irrigation and tillage practices. The experiment each year consisted of four plots, each containing 12 30-m rows, on 76-cm centers. Sugar beet seeds (cv. HH39) coated with BNYVV-infested *Polymyxa betae* were planted in the first 3 m of the two outside rows of each plot and constituted the point sources of inoculum. The remaining plot area was planted with uninfested seeds. Plots were furrow irrigated every 2 weeks. Plant and soil samples were collected from the point source areas and other predetermined locations in each plot before tillage operations. Plant roots were assayed by indirect double-antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) for BNYVV incidence. Soil samples were planted with sugar beet seeds in the greenhouse, and after 10 to 12 weeks, roots of bait plants were assayed for BNYVV. To further evaluate movement, soil samples were collected from the previous locations after tillage events and after a second sugar beet crop before being bioassayed. All plant samples taken from point sources exhibited typical symptoms of rhizomania, and both plant and soil samples tested positive for BNYVV in DAS-ELISA tests. Out of 336 plants collected in the field from non-point-source areas, only 1 tested positive. Before tillage events, 2% of the soil samples were positive for BNYVV for the first experiment and 0.9% tested positive the second, suggesting negligible movement of viruliferous *P. betae* by irrigation. After tillage and harvest operations, 9 and 6% of the soil samples were infested for the first and second experiments, respectively. After a successive sugar beet crop, 15% of the soil samples were positive for BNYVV in the first experiment and 12% in the second. Our results show that physical movement of soil during tillage and harvest operations exert a much greater influence on spread of BNYVV than furrow irrigation, which contradicts the generally accepted concept that viruliferous *P. betae* is rapidly disseminated by irrigation.

**HARVESON, R.M. and C.M. RUSH. 1997. Genetic variation among *Fusarium oxysporum* isolates from sugar beet as determined by vegetative compatibility.** *Plant Dis.* 81:85-88.

One hundred sixty *Fusarium oxysporum* isolates were collected over a 3-year period (1992 to 1994) from diseased sugar beet and pigweed plants from seven counties in Texas. Disease symptoms on sugar beet included root-tip-rot symptoms with wilting and vascular necrosis, and wilting and vascular necrosis only. Pathogenicity testing on sugar beets indicated that 132 isolates of the 160 recovered were pathogenic and were considered to be *F. oxysporum* f. sp. *betae* (FOB). Of the 132 isolates of FOB, 28 were initially chosen as testers and paired in all possible combinations to estimate the number of vegetative compatibility groups (VCGs) present. Once VCGs were determined from

the 28 isolates, a nitrate nonutilizing mutant (*nit*) 1 or *nit* 3 from each of the remaining isolates was paired against a Nit M from each of the established VCGs. Thirty-three isolates obtained from other sugar-beet-growing states also were tested for vegetative compatibility. A total of 95 of the 132 isolates of FOB from Texas were assigned to one of seven VCGs identified. Sixty-three isolates were assigned to VCG 1, with VCGs 2 through 7 containing 6, 16, 2, 2, 2, and 4 isolates, respectively. VCGs 1, 3, and 6 were recovered from both sugar beet and pigweed. Two additional isolates collected from Texas in 1987 also belonged to VCG 1. A number of the isolates collected from Texas could not be assigned to any of the seven established VCGs. These included two single-member Nit Ms, 11 self-incompatible isolates, and 24 of unknown affiliation. None of the isolates from any one state were compatible with those from any other state. Results suggest that substantial variation exist among sugar beet isolates of FOB from the U.S., and that these populations of *F. oxysporum* are apparently distinct and endemic to their respective areas.

**RUSH, C.M., K.-B. G. SCHOLTHOF and G.B. HEIDEL. 1997. Similarities between beet soilborne mosaic virus and beet necrotic yellow virus RNA2 nucleotide sequence and genomic organization.** *In*: Proceedings of the Third Symposium of the International Working Group on Plant Viruses with Fungal Vectors, pg. 29-36.

Studies to further define the taxonomic relationship between beet soilborne mosaic virus (BSBMV) and beet necrotic yellow vein virus (BNYVV) were conducted. Two RT-PCR products comprising 4,546 bases from BSBMV RNA2 were sequenced and data were compared with sequence from several closely related viruses. Six putative open reading frames (ORFs) were identified on BSBMV, which were nearly identical in size and position to those of BNYVV RNA2. Best fit comparisons of amino acid sequence homology from each individual ORF of BSBMV and BNYVV revealed a low of 40% identity and 62% similarity in ORF 6 and a high of 81% identity and 90% similarity in ORF 4. Sequence homology of BSBMV with other furoviruses or viruses possessing triple gene block sequences rarely exceeded 30% identity. Sequence identity of the coat protein region from two isolates of BSBMV exceeded 98% even though the two isolates are serologically distinct. Similarities between BSBMV and BNYVV suggest they represent a sub-group of the furoviruses.

**MICHELS, G.J. Jr., and C.M. RUSH. 1996. Effects of Planting Time and Chemical Control on the High Plains Disease of Corn.** *In*: Proceedings High Plains Disease Symposium. pg. 37-47

The High Plains Disease is a virus-like disease of unknown etiology that attacks corn and wheat. The disease was first observed in Texas on sweet corn in a nursery at Bushland, Texas, in the summer of 1993. The disease causes symptoms similar to a mosaic virus with yellowed leaves, stunted plants, and eventual plant death. Infected plants exhibit symptoms early, and may produce a tassel when less than two feet tall. The disease is transmitted to corn by the wheat curl mite (*Eriophyes tulipae* Keifer). This has been

shown to be true through laboratory experiments where mites from disease-free wheat plants were moved to infected wheat and then to disease-free corn. Disease-free mites were also placed on infected corn plants and moved to uninfected wheat. In all cases, the mites picked up and transferred the disease. Using the same techniques, leafhoppers, planthoppers and thrips did not transfer the disease.

The most likely cycle for disease transmission to corn is by mites leaving infected wheat in the spring of the year as the wheat matures. The mites are wind blown into corn fields where they transmit the disease. The mites also move to native grasses which can harbor the disease. It is assumed that the mites move from native grasses or volunteer wheat into fall-sown wheat fields to complete the cycle.

**PICCINNI, G., C.M. RUSH, K.M. VAUGHN, and M.D. LAZAR. Effects of common root rot on several closely related wheat lines differing for yield response to drought.** ASA/CSSA/SSSA Meeting in Indianapolis, Indiana on Nov. 3-8, 1996.

Common root rot caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker is a disease of wheat (*Triticum aestivum* L.) associated with plant stress. Several wheat lines closely related to TAM 107 and three cultivars (Siouxland, TAM 200, and TAM 107) known to differ with respect to drought tolerance were tested in a two-year dryland field study to evaluate whether the observed variation in drought tolerance was associated with susceptibility to *B. sorokiniana*. The effect of imazalil, a seed treatment for the control of common root rot, was also evaluated. The crop was planted in soil naturally infested with *B. sorokiniana*. In March, plants were evaluated for disease incidence and severity. At harvest, number of plants, number of heads, and grain weight per meter were evaluated. Grain weight and number of heads per plant were evaluated in order to correlate disease rating of each individual plant with these yield components. Plot yield and test weight were also measured. There were no significant cultivar or closely related lines by seed treatment interactions. Seed treated with imazalil had significantly lower disease index than non-treated seed.

### *Papers Published Since Previous Report*

RODRIGUEZ-BALLESTEROS, O.R., A. MARCON, R.A. FREDERIKSEN, C.M. RUSH, G. HEIDEL, D. JEFFERS, S. KAEPLER, S. JENSEN. 1996. Genetics Of Resistance to High Plains Disease in Maize. *In: Proceedings High Plains Disease Symposium*, pg. 59-77.

MICHEL, G.J. Jr., and C.M. RUSH. 1996. Effects of Planting Time and Chemical Control on the High Plains Disease of Corn. *In: Proceedings High Plains Disease Symposium*. pg. 37-47.

RUSH, C.M., K.-B. G. SCHOLTHOF, and G.B. HEIDEL. 1997. Similarities between beet soilborne mosaic virus and beet necrotic yellow vein virus RNA2 nucleotide sequence and genomic organization. *In: Proceedings of the Third Symposium of the International Working Group on Plant Viruses with Fungal Vectors.* pg. 29-36.

HARVESON, R.M., C.M. RUSH, and T.A. WHEELER. 1996. The spread of beet necrotic yellow vein virus from point source inoculations as influenced by irrigation and tillage. *Phytopathology*, 86:1242-1247.

HARVESON, R.M. and C.M. RUSH. 1997. Genetic variation among *Fusarium oxysporum* isolates from sugar beet as determined by vegetative compatibility. *Plant Dis.* 81:85-88.

RUSH, C.M. and J.L. SHERWOOD. 1997. Biological Control: Viral Control Agents. *In: Environmentally Safe Approaches to Crop Disease Control* (in press).

RUSH, C.M., G. PICCINNI, and R.M. HARVESON. 1997. Cultural Practices: Agronomic Measures. *In: Environmentally Safe Approaches to Crop Disease Control* (in press).

# Etiology and Epidemiology of the Rhizomania Disease Complex

## (BSDF Project 503)

Beet soilborne mosaic virus (BSBMV) was discovered in Texas in 1986 (Liu and Duffus, 1988) and has since been identified in California, Colorado, Idaho, Nebraska, and Wyoming (Rush and Heidel, 1995). It has a host range similar to that of beet necrotic yellow vein virus (BNYVV) and is vectored by *Polymyxa betae*. Studies conducted by Wisler et al. (1994) indicated that BSBMV and BNYVV are serologically related but yet distinct. BSBMV and BNYVV are more similar to each other than to other members of the furoviruses in that most field isolates have quadripartite polyadenylated genomes, capsid protein molecular weights are similar, and probes derived from the 3' end of BNYVV hybridize with BSBMV in northern blots (Heidel et al., 1996; Rush et al., 1993). Because of these similarities, Rush et al. (1993) speculated that BSBMV might be a strain of BNYVV, but cautioned that additional work was required to determine the true taxonomic relationship between the two viruses. In an attempt to further clarify the relationship between BSBMV and BNYVV, studies to determine the nucleotide sequence and genomic organization of BSBMV RNA2 were initiated.

### **Materials and Methods**

**Virus isolates:** Two BSBMV isolates, designated BSBMV-FS and BSBMV-RC, were used. Both were maintained on sugar beets naturally infected by *P. betae*, and all plants exhibited systemic symptoms. BSBMV-FS reacts normally with BSBMV polyclonal antiserum in DAS-ELISA, but BSBMV-RC gives a negative or borderline positive reaction (Rush and Heidel, 1995). However, RT-PCR products can be amplified using BSBMV-RC as a template and BSBMV specific primers (Rush et al., 1994).

**RT-PCR:** Oligonucleotide primers for use in reverse transcriptase-polymerase chain reactions (RT-PCR) were synthesized by the Gene Technologies Lab (Texas A&M University, College Station, TX). Primers were derived from BNYVV RNA 1-4 sequences using published data from European isolates (Bouzoubaa et al., 1986). Total RNA was extracted from sugar beet leaves systemically infected with BSBMV-FS and used as a template in combination with an oligo-dT primer for first strand BSBMV cDNA synthesis in reverse transcriptase reactions. The BSBMV-FS cDNA was then used in RT-PCR, with various combinations of the BNYVV primers. In previous studies, certain BNYVV primer combinations were shown to amplify BSBMV cDNA (Rush et al., 1994). Amplification of BSBMV-FS cDNA was carried out in 50  $\mu$ l reactions using 5  $\mu$ l cDNA, 10 pmol of each primer, 0.2 mM of each dNTP and 5 U *Taq* DNA polymerase in a reaction buffer provided with the enzyme (Robertson et al., 1991). PCR



products were visualized after electrophoresis in a 1% agarose gel by staining with ethidium bromide.

**Sequencing and analysis:** Both strands of BSBMV-FS PCR products were directly sequenced at the Gene Technologies Lab using the ABI PRISM Dye Terminator Cycle Sequencing Core Kit on the ABI 373 Automated Sequencer. Sequence data was analyzed using the BLAST program (Gish and States, 1993). Putative open reading frames (ORFs) were identified using the DNA Strider 1.2 program, and predicted starts and stops were further defined based on BNYVV RNA2 sequence in GenBank. A primer pair was developed from BSBMV-FS sequence to amplify the putative ORF1 of BSBMV-RC. This primer pair was used with BSBMV-RC RNA in RT-PCR and resulting dsDNA products of the predicted size were sequenced and compared with the BSBMV-FS sequence. The amino acid sequence from each individual ORF of BNYVV RNA2 was used for best fit analysis with BSBMV sequence and also sequence from beet soilborne virus, peanut clump virus, potato mop top virus, barley stripe mosaic virus, and *Nicotiana velutina* mosaic virus.

**Westerns:** Total plant extracts were denatured and resolved on 10% SDS-polyacrylamide gels followed by transfer to nitrocellulose membrane and immunoanalyses as previously described (Scholthof et al., 1995). For western blots, BSBMV antiserum was used at 1:20,000 dilution in 5% milk with TBS, pH 7.4 and 0.02% Tween-20. The secondary antibody was used at 1:5,000 as goat anti-rabbit horseradish peroxidase and developed with chemiluminescent substrates (SuperSignal CL-HRP substrates, Pierce, Inc., Rockford, IL). Exposure was for 5 seconds on X-ray film (Scholthof et al., 1995).

## ***Results and Discussion***

**RT-PCR:** Use of BNYVV primers with BNYVV cDNA as template gave RT-PCR products of the expected size. When BSBMV-FS cDNA was used as template, multiple RT-PCR products were formed, but usually not of the predicted size, indicating non-specific binding. Initial attempts at cloning the RT-PCR products failed, so direct sequencing of the products was initiated. The first PCR product selected for sequencing was from the 3' end of RNA2 and included the poly (A) region. This product was approximately 1,450 bp in length, excluding the poly (A) tail. Following preliminary sequencing of this product, a reverse primer was developed from the sequence near the 5' end and used in additional RT-PCR reactions with BNYVV primers. The largest product amplified in these reactions, approximately 3,500 bp, was selected for sequencing.

**Sequence analysis and genomic organization of BSBMV-FS:** Sequence of the two RT-PCR products overlapped and together represented 4,546 continuous nucleotides (nt) from BSBMV-FS. When this sequence was entered into the BLAST program, best fit was with BNYVV RNA2. Based on measurements from RNA gels, the 4,546 nt represents a near full-length sequence of BSBMV-FS RNA2 and differs from the reported length of BNYVV RNA2 by only 66 nt (Bouzoubaa et al., 1986).

Computer assisted analysis of potential coding capacity of BSBMV-FS sequence indicated further similarities with BNYVV RNA2. Six putative ORFs of similar size and position to those of BNYVV RNA2 were identified. Coordinates of the putative ORFs of BSBMV-FS and estimates of their translation products are shown in Table 1. The first ORF begins at nt (53) and ends with an UAG at nt 628, to give a protein of 20,953 daltons. Following the stop at 628, an in-phase coding region extends to nt 1863 to encode a predicted readthrough translation product of 75,580 daltons. These first two ORFs are analogous to the coat protein region and readthrough of BNYVV and have been detected in western blots using antiserum developed against BSBMV coat protein. The remaining four ORFs of BSBMV-FS are also similar in size and position to those on BNYVV RNA2.

**Table 1.** Predicted coordinates of BSBMV-FS RNA2 ORFs

ORF	First AUG (nt)	Termination (nt)	Protein (Mr)
1	53	628	20,953
2	53	1,863	75,580*
3	2,110	3,180	38,990**
4	3,180	3,536	12,602
5	3,520	3,918	14,660
6	3,946	4,308	13,719

\* Assuming readthrough of ORF 1

\*\* Modification of one nt in the BSBMV-FS sequence increases size of the predicted ORF 3 protein to approximately 42,000 daltons, the same as ORF3 of BNYVV RNA2.

BLAST analysis of putative BSBMV-FS ORFs showed greater amino acid sequence homology with BNYVV than with several other related viruses. The highest degree of homology was in ORF 4, which exhibited 81% identity and 90% similarity. The lowest homology was with ORF 6 which codes for a 14 kDa non-structural protein in BNYVV and had only 40% amino acid sequence identity with the analogous region in BSBMV-FS. The coat protein region of BSBMV-FS and BNYVV had 59% amino acid identity and 72% similarity. All ORFs of BSBMV-FS had regions which exhibited greater than 90% amino acid sequence homology with analogous ORFs of BNYVV. When amino acid sequence from specific ORFs of BNYVV were compared by best fit analysis to BSBMV-FS and several other related viruses, BNYVV was more similar to BSBMV-FS than to any of the other viruses (Table 2).

**Table 2.** Best fit comparisons between specific BNYVV ORF regions and comparative regions of several related viruses

BNYVV	21 kDa	42 kDa	13 kDa	15 kDa
BSBMV	<b>59(72)*</b>	<b>74(86)</b>	<b>81(90)</b>	<b>65(78)</b>
PCV	18(40)	30(51)	32(51)	20(44)
PMTV	19(39)	29(50)	37(56)	20(46)
NVMV	21(42)	26(53)	40(62)	23(49)
BSMV	21(43)	27(50)	42(63)	12(42)
BSBV	14(34)	29(50)	39(56)	23(47)

\* Values represent percent amino acid identity and similarity

**Sequence comparisons between BSBMV isolates FS and RC:** The primer pair based on sequence from BSBMV-FS ORF 1 region amplified a RT-PCR product of the predicted size when using BSBMV-RC cDNA as a template. Sequence comparisons between the two isolates indicated nucleotide homology exceeding 98%. Only four amino acid differences were detected between the two isolates. Although BSBMV antiserum gives negative or borderline positive readings in DAS-ELISA tests, the same antiserum detected BSBMV-RC in western blots.

Because of its polyadenylated quadripartite genome, BNYVV has long been considered an outlier among the furoviruses. However, with BSBMV and the serologically distinct BSBMV-RC, there are now three serologically distinct members with polyadenylated quadripartite genomes. Furthermore, the genomic organization between BNYVV RNA2 and BSBMV RNA2 is practically identical. Because of the many similarities between BSBMV and BNYVV and their differences from other furoviruses, we believe a sub-group within the furoviruses should be created with BNYVV as the “type” member.

### *Acknowledgments*

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# **SUGARBEET RESEARCH**

## **1996 Report**

### **Section G**

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# **Genetic Distance and Diversity Within and Among Sugar Beet Breeding Lines Measured by Randomly Amplified Polymorphic DNA (RAPD) Markers**

**M. Wang, Postdoctoral Research Associate  
I. L. Goldman, Assistant Professor  
(University of Wisconsin-Madison)**

Estimations of genetic distance between cultivated *Beta* accessions have been attempted by several researchers. Morphological traits including growth habit, mode of branching, leaf shape, leaf color, reproductive system, and ploidy level have facilitated the classification of the four sections (*Beta*, *Corollinae*, *Nanae*, and *Procumbens*) within the *Beta* genus, and 15 species among sections, but did not exhaustively reveal the relationship among species (Buttle, 1977; Frese and von Hintum, 1989). Recently molecular markers have been employed to answer such questions. Isozyme polymorphisms indicated significant differences between fodder beet and sugar beet, but not between monogerm sugar beet and multigerm sugar beet (Nagamine et al., 1989a). RFLP analyses showed large amounts of genetic variability between cultivars in *Beta vulgaris* (Mita et al., 1991; Nagamine et al., 1989b). Restriction profiles of chloroplast and mitochondrial DNA revealed identical restriction patterns for fodder beet, red beet, leaf beet, Swiss chard and sugar beet, except sugar beet with S-cytoplasm (Ecke and Michaelis, 1990). Restriction patterns of plastid DNA revealed different patterns between three wild species in the *Beta* genus and cultivated *Beta vulgaris*, lines and identical patterns for varieties and lines of *Beta vulgaris* despite their strong morphological variation. DNA fingerprinting revealed low genetic similarity (GS) between sugar beet and other wild species in section *Beta*, high GS among sugar beet cultivars and

breeding lines, and low GS between fodder beet and sugar beet or red beet (Jung et al., 1993). These studies have generally revealed limited variation among cultivated sugar beet accessions, however they were of limited value for measuring the magnitude of genetic variation among genotypes within sugar beet or red beet cultivars or breeding lines. Knowledge of variability patterns between cultivated sugar beet accessions should provide breeders with information regarding genetic similarity of individuals in breeding populations.

Among molecular markers, random amplified polymorphic DNA (RAPD) markers have been found: 1) technically simpler and inexpensive, and reliable in reproducing banding patterns (dos Santos et al., 1994); 2) to have a low frequency of random errors (<2%) among replicate DNA samples scored for RAPD markers (Skroch and Nienhuis, 1995a; Spooner et al., 1996); and 3) to be preferred in applications where the relationships between closely-related breeding lines are of interest (Hallden et al., 1993). Furthermore, RAPD marker have been used as a tool for estimating genetic relationships in many crop species: *Brassica oleracea* (dos Santos et al., 1994); *Phaseolus vulgaris* (Skroch et al., 1992; Beebe et al., 1995; Skroch and Nienhuis, 1995b); *Phaseolus lunatus* (Nienhuis et al., 1995); and *Cynara scolymus* (Tivang et al., 1996).

Genetic variability among plants in a breeding population can directly influence gain from selection. In addition, the level of genetic homogeneity in a population of plants used as a parent of a hybrid cultivar can affect the uniformity of resulting hybrids. Since beet is self-incompatible, direct inbreeding is possible in beet populations only through use of  $S^f$  allele in the homozygous recessive condition. Without this allele, only sib-mating can be accomplished. In practice, sugar beet breeding programs do not make use of this allele for inbreeding and populations are typically maintained as sib-mated masses. By contrast, the red beet breeding program at the University of Wisconsin made use of the  $S^f$  allele allowing direct inbreeding

of red beet plants. Differences in genetic distance among individual plants should reveal how breeding practices have influenced genetic similarity within breeding populations.

The objectives of this study were to estimate 1) the genetic relationship among and within 16 entries of sugar beet; and 2) the relative magnitudes of genetic diversity among these entries, using RAPD molecular markers.

## **Materials and Methods**

**Plant germplasm.** Fourteen sugar beet breeding lines and two red beet accessions, one F<sub>1</sub> hybrid and one inbred line, were used in this study (Tab. 1). The two red beet accessions were included for comparison within *Beta*. The fourteen sugar beet lines were randomly selected from the breeding program at American Crystal Sugar Company (ACS, Moorhead, MN) were P types used in F<sub>1</sub> hybrid production. These lines represented a range of sugar content and ploidy level (tetraploids and diploids). Red beet accessions were comprised of the commercial F<sub>1</sub> hybrid Red Ace (Alf Christianson Seed Company, Mt. Vernon, WA) and the inbred line W425B, developed at the University of Wisconsin-Madison.

**Plant DNA isolation.** DNA was extracted from fresh leaves of 3 weeks old single beet seedlings by the PEX method described by Skroch and Nienhuis (1995). Six individual DNA isolations from each of sixteen population samples (entries) of *Beta vulgaris* were used in this RAPD analysis.

**Primer selection.** An arbitrary set of fourteen DNA isolates represent the sixteen population samples was evaluated for polymorphism using 30 10-base RAPD primers (Operon Technologies, Alameda, Calif.). Twenty-one primers were selected based on the consistency and clarity of polymorphic bands. Operon primers AA03, AA10, AA12, AA14, AB01, AB09, AB11, AB17, AB18, AC07, AC15, AC19, AC20, AD02, AE07, AE08,

AE09, AF11, AF14, AI04 and AI17 were used in this RAPD analysis.

***RAPD analysis.*** Each individual DNA isolate was used as a template for PCR amplification. Reactions were run in 96-well Falcon assay plates. The PCR protocol was as described by Eagen and Goldman (1995) with minor modifications. Every RAPD reaction was carried out in volumes of 21 ml using the following reagents: 10 ng of genomic DNA template, double-distilled H<sub>2</sub>O, 10x buffer, 10 mM MgCl<sub>2</sub>, 0.2% BSA, 10 mM primer, 1.25 mM each dNTP's and 0.6 unit of *Taq* polymerase (Promega Corp. Madison, WI). Two drops of mineral oil were added to wells to minimize evaporation during reaction. Controls containing no template DNA were conducted with each reaction plate. The reactions were performed in a Thermal Controller (MJ Research, MN) programmed for 42 cycles after initial denaturation for 60 sec. at 94<sup>0</sup>C. Each cycle consisted of 30 sec. at 92<sup>0</sup>C, 60 sec. at 36 , and 60 sec. at 72<sup>0</sup>C. The amplification fragments were separated by electrophoresis on 1.6% low EEO agarose gels stained via ethidium bromide, photographed under ultraviolet light. The sizes of fragments were ranged from 200-2000 base pairs. A 100 base pair ladder was used as a molecular weight standard on each gel. Polymorphic bands were classified as present (1), absent (0), or missing (.) based on the resolution and degree of amplification.

***Genetic distance.*** Genetic distance (GD) matrix was completed using a program written in the "C" programming language provided by Paul W. Skroch. Estimates of GD were calculated for all 96 individual samples based on the complement of the simple matching coefficient (Gower, 1985), given as

$$GD (i, j) = \sum^N (i \neq j) / [\sum^N (i \neq j) + (\sum^N (i = j))].$$

where GD is the measure of genetic distance between entry  $i$  and  $j$ , while  $\sum^N (i \neq j)$  and  $\sum^N (i = j)$  are the total number of sources discordant and concordant between entry  $i$  and  $j$ , respectively, over all  $N$  bands considered. A GD value of 0.0 and 1.0 indicates no and maximal RAPD difference between two entries, respectively.

The 96 x 96 triangular matrix of GD value was analyzed by unweighted classical multidimensional scaling (MDS) and displayed as a two dimensional MDS plot (Young and Hamer, 1987). Variance analysis for GD estimates was performed using the analysis of molecular variance (amova) and an F-test modified from the amova was used to test the significance of differences among and within the sixteen population samples (Excoffier et al., 1992; Long, 1986).

**Genetic diversity.** A genetic model of a single locus with two alleles was assumed for each polymorphic band. For each RAPD band, marker diversity was calculated as Nei's gene diversity ( $H_s$ ) at a locus (Nei, 1987):

$$H_s = (1 - \sum x_i^2) n / n - 1 = 2pqn / (n - 1)$$

where  $p$  and  $q$  is the frequency of presence and absence of band at a locus, respectively, and  $n$  is the number of individuals evaluated.

The significance of differences among 16 population samples for the mean of  $H_s$  and the mean number of polymorphic RAPD band per primer were determined by one-way analysis of variance separately.

## Results

**RAPD polymorphism.** Twenty-one primers were scored for 2-13 polymorphic bands per primer, resulting in a total of 201 bands. The best six primers, AA10, AB01, AB11, AB18, AE08 and AF11 contributed 13, 11, 11, 11, 11 and 11 RAPD bands, respectively. At least one polymorphic RAPD band was found

for all 9648 parity comparisons of individual samples. The F-value of 9.92 for mean number of polymorphic bands per primer indicated significantly ( $p=0.0006$ ) different polymorphism existing in the sixteen populations. The two red beet populations had significantly lower levels of polymorphism than all sugar beet populations (Table 4). The mean number of polymorphic bands scored per primer ranged from 3 to 5 for all sugar beet populations whereas W425B and Red Ace had less than 1 polymorphic band per primer.

*Genetic relationship revealed by MDS plot.* MDS is a class of methods for estimating the coordinates of a set of objects in a space of specified dimensionality from data measuring the distance between pairs of objects (SAS/STAT, 1996). The genetic relationships among sixteen population samples were displayed in a two dimensional MDS plot based on the MDS analysis for 96 x 96 matrix of genetic distance (Fig. 1). The  $R^2$  for the proportion of variation explained by the two dimensional MDS was 95.7% with a stress factor of 0.11, which indicates a good fit between the two dimensional representation of relationships among sixteen population samples and the original genetic distance matrix. In the MDS plot, ACS8700691, ACS9100272, ACS9300176, ACS7900923 and ACS9100168 formed five discrete clusters, respectively. ACS9200067 and ACS9400461 shared the same cluster. The remaining six sugar beet populations ACS9100209, ACS9090346, ACS9100128, ACS8900011, ACS8800705, and ACS8300047 were scattered around the six clusters. W425B and Red Ace formed two individual tightly closed clusters, separated from the sugar beet clusters.

Amova analysis showed highly significant ( $p < 0.0001$ ) variation among the sixteen population samples (Table 2). ACS9090346 had the highest mean genetic distance (0.327) and ACS7900923 had the lowest (0.281). W425 (0.315) and Red Ace (0.314) were in the middle of the range and were significantly

different from seven sugar beet populations, but were not significantly different from each other. The F-test values based on genetic distance (Table 3) revealed no significant difference within Red Ace, W425B, ACS8700691, ACS9100168, ACS9200067, and ACS9400461. The highest levels of significance ( $p < 0.0001$ ) for genetic variation were found within ACS9100209, ACS9090346, ACS9100128, ACS8900011, ACS8800705, ACS8300047, and ACS9100272 while relatively lower levels of significance ( $p=0.01$ ) were found in ACS8900245, ACS9300176, and ACS7900923.

**Genetic diversity.** A one-way analysis of variance for Hs (Table 4) revealed significantly ( $p < 0.0001$ ) different levels of genetic diversity among the sixteen populations. W425B and Red Ace had the lowest Hs values, 0.029 and 0.021, respectively, which were not significant different from each other. Ten of the sugar beet populations had seven-fold higher Hs levels than that of the two red beet populations. ACS9090346 represented the highest average Hs (0.278) while ACS7900923 represented the lowest (0.154) in the fourteen sugar beet populations.

## Discussion

Almost identical restriction patterns of the plastid DNA were observed among varieties of *Beta vulgaris* (Fritzsche et al., 1987). Remarkably high genetic similarity estimates were found for sugar beet cultivars and breeding lines based on DNA fingerprinting (Jung et al., 1993). Although substantial variation was reported between *Beta vulgaris* cultivars in an RFLP study (Mita et al., 1991), it was based on only two cultivars. In this study, the distribution of the clustering and scattering patterns in the two dimensional MDS plot illustrated the genetic uniformity and diversity among and within 16 beet populations. The populations Red Ace, W425B, ACS9100168, ACS9400461, ACS9200067, and ACS8700691, each exhibited its own cluster in the MDS plot, nonsignificant variation within each population



and very low levels of average Hs. The separation among these clusters was obvious. These results suggest that 1) fair uniformity exists within each population and large variability exists among populations; 2) these populations had been inbred and selected for different traits and different genetic backgrounds were likely involved in their development; 3) W425B and Red Ace represented their own clusters, which is consistent with their known differences from sugar beet. The populations ACS9100209, ACS9090346, ACS9100128, ACS8900011, ACS8800705, and ACS8300047, which exhibited the most scattering in the MDS plot showed the most significant ( $p < 0.0001$ ) variation within each population and also had the highest levels of Hs. These results indicate that significant amount of genetic diversity exists within each of these populations and among these populations based on GD and HS. These results were conflicting with reports from Fritzsche's group and Jung's group, which could be due to different materials being used, or different methodologies being employed in analysis. Fritzsche's group used plastid DNA in their analysis. Plastid DNA is much more conservative compared with nuclear DNA and much less prone to rapid evolutionary change compared to morphological changes (XXXXXX Fritzsche et al., 1987). Results from Jung's group were based more on the modern sugar beet cultivars with characters of monogerm and 0 type (Jung et al., 1993). The narrow genetic basis was known in modern sugar beet cultivars due to the introduction of monogerm and cytoplasmic male sterile from two single genetic sources.

Savitsky proposed a theory that higher ploidy level is superior than diploid with respect to sugar content (McFarlane, 1993). In this study, we found sugar content was not associated with ploidy levels or with the mean genetic distance and average Hs. High and low sugar content populations, as well as 4x and 2x ploidy populations were randomly distributed in the MDS plot with scatter and cluster formations. For

instance, high sugar content populations ACS9100128 (2x) with high Hs, ACS9100168 (2x) with medium Hs and ACS8300047 (4x) with high Hs had scatter cluster, and scatter patterns, respectively; whereas low sugar content populations ACS9090346 (2x) with high Hs and ACS7900923 (4x) with low Hs appeared in scatter and cluster, respectively.

Inspection of the mean number of polymorphic bands and average Hs values together (Table 4), revealed that the higher polymorphic band numbers corresponded to higher average Hs values in the sixteen populations. ACS9090346 had the highest average Hs (0.2780) and the highest number of polymorphic bands (5.38), while Red Ace had the lowest average Hs (0.021) and the lowest number of polymorphic bands (0.43). The correlation coefficient for these 2 variables were estimated as 0.95. A similar phenomena was also observed in artichoke (*Cynara scolymus* L.) (Tivang et al., 1996). On the other hand, 87.5% of total parity comparisons of individual samples had at least three polymorphic bands. These results indicate that RAPD marker variation can be easily detected among and within populations and that the RAPD marker is a simple and very useful tool for investigation of genetic relationship within species and among cultivars.

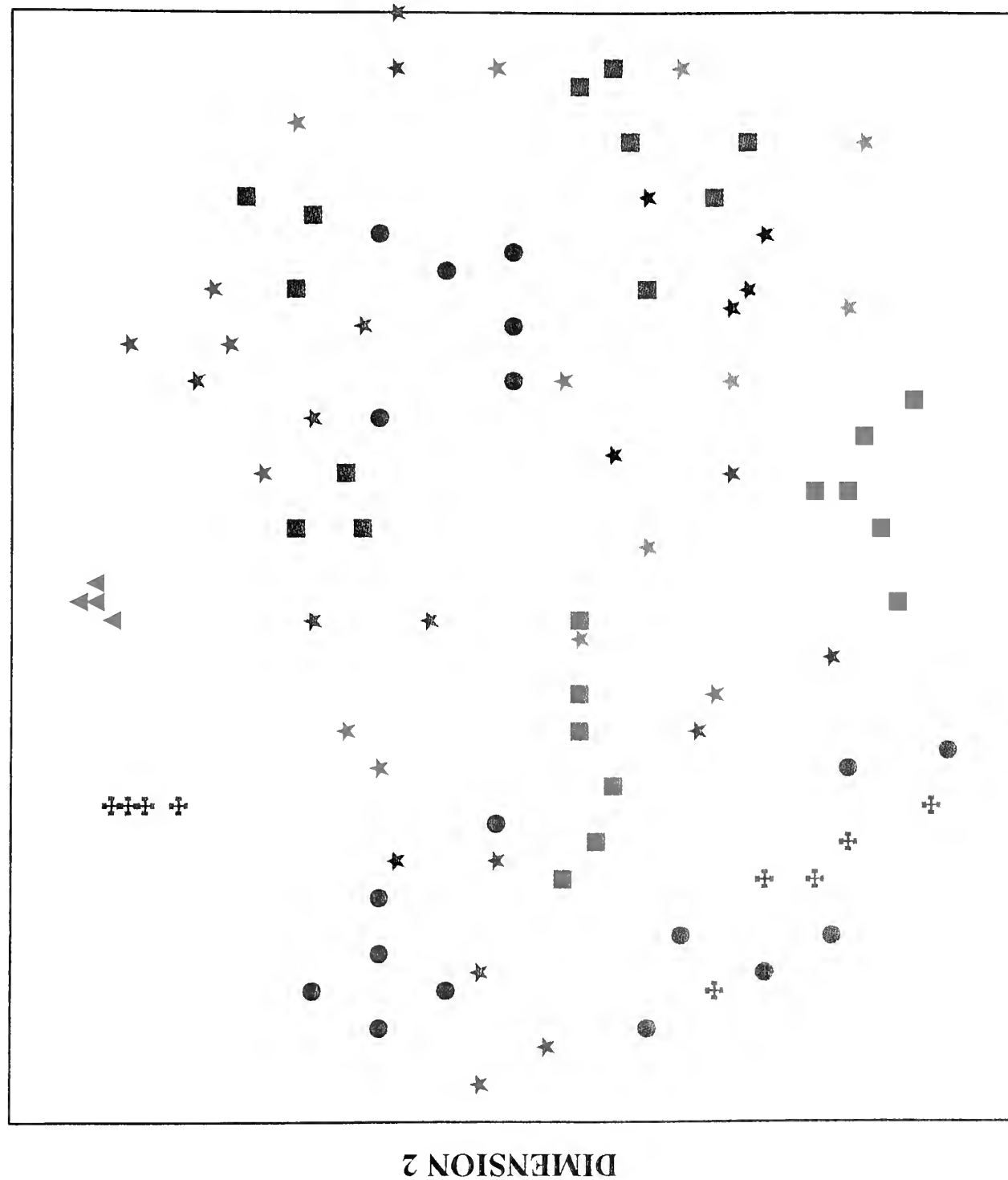
The amount genetic diversity among and within populations found in this study based on RAPD markers should provide very important information to the sugar beet breeder because the genetic variation present in a breeding population ultimately determines the breeding method and potential gain from the selection.

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★	8800705
★	9090346
▲	Red Ace
★	9100128
■	8900245
★	8900011
⊕	W425
●	8700691
■	9300176
●	9100168
■	7900923
★	9100209
★	8300047
■	9100272
●	9200067
⊕	9400461

Table 1. Sugarbeet breeding lines and red beet cultivars sampled for analysis with RAPD markers.

Population	Type	Background	Ploidy	Sugar Content	O or P type
ACS7900923	sugar beet	BL <sup>z</sup>	4x	low <sup>y</sup>	P
ACS8300047	sugar beet	BL	4x	high	P
ACS8700691	sugar beet	BL	2x	medium	P
ACS8800705	sugar beet	BL	2x	high	P
ACS8900011	sugar beet	BL	2x	medium	P
ACS8900245	sugar beet	BL	2x	high	P
ACS9090346	sugar beet	BL	2x	low	P
ACS9100128	sugar beet	BL	2x	high	P
ACS9100168	sugar beet	BL	2x	high	P
ACS9100209	sugar beet	BL	2x	medium	P
ACS9100272	sugar beet	BL	2x	high	P
ACS9200067	sugar beet	BL	4x	medium	P
ACS9300176	sugar beet	BL	2x	medium	P
ACS9400461	sugar beet	BL	2x	medium	P
W425B	red beet	Inbred	2x	unknown	O
Red Ace	red beet	F <sub>1</sub> Hybrid	2x	unknown	?

<sup>z</sup> Breeding Line

<sup>y</sup> Based on assessment by American Crystal Sugar

Table 2. Comparisons of mean genetic distance among sixteen population samples of *Beta vulgaris*, ranked from highest to lowest.

Population	Mean Genetic Distance
ACS9090346	0.327
ACS9400461	0.323
ACS9200067	0.320
ACS9100128	0.320
ACS9100272	0.319
ACS8900011	0.319
ACS9100168	0.317
W425	0.315
Red Ace	0.314
ACS9100209	0.307
ACS9300176	0.305
ACS8700691	0.302
ACS8300047	0.302
ACS8900245	0.297
ACS8800705	0.297
ACS7900923	0.281
<b>LSD</b> <sub>0.05</sub>	0.008



Table 3. Mean squared deviation from the analysis of molecular variance for genetic distance within each of sixteen population samples of *Beta vulgaris*.

Population	df	MSD <sup>z</sup>
ACS9100209	5	0.057 **** <sup>y</sup>
ACS9090346	5	0.033 ****
ACS9100128	5	0.033 ****
ACS8900011	5	0.024 ****
ACS8800705	5	0.024 ****
ACS8300047	5	0.023 ****
ACS9100272	5	0.023 ****
ACS8900245	5	0.017 **
ACS9300176	5	0.014 **
ACS7900923	5	0.014 **
ACS8700691	5	0.011 ns
ACS9200067	5	0.010 ns
ACS9400461	5	0.007 ns
ACS9100168	5	0.006 ns
W425	5	0.007 ns
Red Ace	5	0.001 ns

<sup>z</sup> Mean squared deviation in amova equal to conventional Mean square in anova (Excoffier et al., 1992).

<sup>y</sup> ns, \*\*, \*\*\*\* Nonsignificant and Significant at 1% and 0.01%, respectively.

Table 4. Average gene diversity and polymorphic bands per primer based on RAPD marker data collected from sixteen population samples of *Beta vulgaris*. The F-values were estimated based on the variance analyses for both characters in sixteen population samples.

Population	Hs <sup>z</sup>	Number of bands <sup>y</sup>	Bands per primer <sup>z</sup>
ACS9090346	0.278	113	5.38
ACS9100128	0.267	112	5.33
ACS8300047	0.260	115	5.48
ACS9100209	0.242	103	4.90
ACS8900011	0.236	102	4.86
ACS8800705	0.224	99	4.71
ACS9300176	0.215	91	4.33
ACS8700691	0.215	91	4.88
ACS9400461	0.215	90	4.29
ACS9100168	0.214	94	4.48
ACS9100272	0.199	86	4.10
ACS8900245	0.198	83	3.95
ACS9200067	0.186	80	3.81
ACS7900923	0.154	62	2.95
W425	0.029	11	0.52
Red Ace	0.021	9	0.43
<b>LSD<sub>0.05</sub></b>	0.046		0.14
df	15		15
F-value	19.9		9.92
P < F	0.0001		0.0006

<sup>z</sup> Nei's gene diversity computed for each population sample average over 201 polymorphic loci.

<sup>y</sup> Mean number of RAPD bands polymorphic within each population sample.

<sup>x</sup> Mean number of polymorphic bands scored per primer for 21 primers evaluated.



# **SUGARBEET RESEARCH**

## **1996 Report**

### **Section H**

Northern Illinois University  
DeKalb, Illinois

Drake C. Stenger

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This research is supported in part by funds provided through the Beet Sugar  
Development Foundation (Project 730)



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# Genetic Diversity of Beet Curly Top Virus in Nursery and Field Populations

## BSDF Project 730

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Beet curly top virus (BCTV) is a leafhopper-transmitted geminivirus infecting dicot plant hosts. Three distinct strains of BCTV are known and have been studied at the molecular level. In 1986, Stanley et al. (6) reported the complete nucleotide sequence of a cloned BCTV genome (pBCT028) recovered from the California isolate of BCTV. Stanley, et al. (6) also determined that the genome of BCTV was comprised of a single DNA molecule of approximately 3000 nucleotides that contained seven genes encoding viral proteins necessary for replication, packaging, systemic movement, and vector transmission. Subsequently, DNA clones (pLOGAN, pCFH, and pWORLAND) derived from three additional laboratory-maintained isolates of BCTV (Logan, CFH, and Worland) have been characterized for genotypic and phenotypic properties (10). Infectivity assays and restriction endonuclease mapping indicated that the cloned Logan and California genomes may be considered as genotypic variants of the same strain (designated here as Cal/Logan). The cloned Logan genome is also very similar to the cloned California genome in nucleotide sequence (4,13).

In contrast, nucleotide sequence comparisons (7) indicated that cloned genome of pCFH may be considered as representing a second strain of BCTV that is distinct from the Cal/Logan strain. The CFH strain has since been demonstrated to be different from the Cal/Logan strain in pathogenicity on the experimental hosts *Nicotiana benthamiana* Domin. (11), and *Arabidopsis thaliana* (L.) Heyhn. (5). The CFH strain also possesses *cis*- and *trans*-acting elements governing DNA replication that are distinct from the Cal/Logan strain that are not separately interchangeable among the two strains (2,3,8). Despite these differences, both the CFH and Cal/Logan strains produce severe disease on sugar beet and cannot be distinguished from one another by visual inspection of symptoms. Although the origin of the isolate from which the CFH genome was cloned is unknown (10), a recent study (9) determined that genotypic variants of the CFH strain were present in BCTV-infected sugar beet grown in the Texas panhandle region during 1994.

The cloned viral insert of pWORLAND represents a third strain of BCTV that is noticeably less virulent on sugar beet relative to the Cal/Logan and CFH strains, although the Worland strain does retain the typical wide host range of BCTV and is capable of inducing severe disease symptoms on other hosts under experimental conditions (10). The mild symptom phenotype of the Worland strain may cause difficulties in visually assessing the incidence of this strain in sugar beet plantings. Restriction endonuclease mapping (10) and the inability to mobilize and amplify a Logan-derived defective-interfering (DI) DNA molecule present as a tandem repeat integrated into a chromosome of transgenic *N. benthamiana* (8) further suggests that the Worland strain has replication specificity determinants incompatible with that of the Cal/Logan strain (2,3). Unpublished experiments indicate that the CFH and Worland strains have replication specificity elements that are compatible in heterologous combinations. DNA sequence analysis of the Worland genome (13) indicates that this strain of BCTV is distinct from both the Cal/Logan and CFH strains.

BCTV is widespread throughout the western United States and continues to cause losses to the sugar beet industry despite continuous efforts to select cultivars with improved tolerance or partial resistance to BCTV since the 1920's (1). The sugar beet industry maintains two nursery facilities in Idaho (the BSDF and nearby Betaseed nurseries) dedicated to the assessment of cultivar response to BCTV infection. However, the BCTV isolates used by the industry for this purpose



have not been characterized with respect to strain composition or genetic complexity. Furthermore, the distribution and occurrence of the three strains of BCTV present in contemporary sugar beet culture throughout the western United States has not been examined. Research conducted during the past year was aimed at addressing these deficiencies in knowledge. This report details a summary of research in which the genotypic properties of BCTV isolates used by the industry to evaluate sugar beet cultivar response to infection were characterized and compared to field isolates of the virus collected from commercial sugar beet plantings in eight western states during 1994 and 1995.

Four nursery isolates obtained from the BSDF and Betaseed nurseries were examined for genotypic complexity and strain composition through the analysis of full length DNA clones recovered for each isolate. A complete description of this work is available in the published literature (13). Briefly, the results indicated that each of the nursery isolates contained genotypic variants of the Cal/Logan and CFH strains of BCTV. One nursery isolate also contained a genotypic variant of the Worland isolate. Therefore, it would seem that the industry is using an appropriate collection of BCTV isolates in which all of the known strains of BCTV are present. Modification of the current system used by the industry to evaluate cultivar response to BCTV infection in the Idaho nurseries does not seem warranted.

During 1994 and 1995, isolates of BCTV obtained from commercial fields were collected and examined for strain composition and genetic complexity. A total of 58 isolates (all but four from sugar beet) collected from sixteen localities in eight western states have been examined (Table 1). Restriction endonuclease mapping of DNA clones derived from each isolate have permitted the classification of each cloned genome as minor variants of the known strains of BCTV. A manuscript (12) describing this work has been accepted for publication in *Phytopathology* and will appear in the July or August 1997 issue of the journal. The results of the field survey indicate that the CFH and Worland strains of BCTV are widespread throughout the western United States, and that many minor genotypic variants of each strain exists in nature. Surprisingly, the Cal/Logan strain was not recovered from any of the field samples examined.

The absence of the Cal/Logan strain in the current survey raises several questions: Is the Cal/Logan strain a significant factor in sugar beet production today? Should the industry continue to select for cultivars with tolerance or resistance to the Cal/Logan strain? Caution is urged here. Although the Cal/Logan strain was not recovered from localities surveyed during 1994 and 1995, large areas of the west remain unsampled. In particular, no samples have been obtained from Southern California, Arizona, Nevada, Utah, and Montana. Furthermore, it is not known how the genetic makeup of BCTV populations varies from year to year. Although the Cal/Logan strain may well prove to be a relic of the past, continued sampling of field populations of BCTV would seem prudent.

Table 1. Strain composition of BCTV field isolates.

<u>Isolate</u>	<u>State</u>	<u>Locality</u>	<u>Strain</u>
NC94-2	CA	Modesto	CFH
CA95-1	CA	Firebaugh	CFH
CA95-2	CA	Firebaugh	CFH
CA95-4	CA	Firebaugh	CFH
CA95-9	CA	Firebaugh	CFH
CO95-1	CO	Wiggins	Worland
CO95-3	CO	Wiggins	Worland
CO95-6	CO	Ft. Morgan	Worland
CO95-7	CO	Ft. Morgan	Worland

Table 1. Strain composition of BCTV field isolates. - *continued*

<u>Isolate</u>	<u>State</u>	<u>Locality</u>	<u>Strain</u>
CO95-8	CO	Ft. Morgan	Worland
CO95-9	CO	Ft. Morgan	Worland
CO95-10	CO	Ft. Morgan	Worland
ID95-1	ID	Grandview	CFH
ID95-2	ID	Grandview	CFH
ID95-7	ID	Nampa	CFH
ID95-8	ID	Nampa	CFH
NM95-1	NM	Artesia	CFH
NM95-2	NM	Artesia	CFH
NM95-4	NM	Artesia	CFH
NM95-5 (pepper)	NM	Artesia	Worland
NM95-6 (pepper)	NM	Artesia	Worland
NM95-10 (pepper)	NM	Artesia	Worland
NM95-12 (pepper)	NM	Artesia	Worland
OR95-3	OR	Jameison	CFH
OR95-6	OR	Adrian	Worland
OR95-7	OR	Adrian	CFH, Worland
OR95-8	OR	Adrian	CFH
OR95-9	OR	Adrian	CFH, Worland
OR95-10	OR	Adrian	Worland
T94-1	TX	Bushland	CFH
T94-4	TX	Bushland	CFH
T94-6	TX	Bushland	CFH
T94-7	TX	Bushland	CFH
T94-12	TX	Wildorado	CFH
T94-14	TX	Wildorado	CFH
T94-16	TX	Wildorado	CFH
T94-19	TX	Wildorado	CFH
T94-23	TX	Wildorado	CFH
T94-28	TX	Hereford	CFH
T94-30	TX	Hereford	CFH
T95-1	TX	Bushland	CFH
T95-2	TX	Bushland	CFH
T95-3	TX	Bushland	CFH
T95-4	TX	Bushland	CFH
WA95-1	WA	Mapton	Worland
WA95-2	WA	Mapton	Worland
WA95-3	WA	Mapton	Worland
ML95-1	WA	Moses Lake	Worland
WD95-3	WY	Worland	CFH
WD95-5	WY	Worland	CFH
WD95-6	WY	Worland	CFH
WD95-8	WY	Worland	CFH
WD95-18	WY	Worland	CFH
WD95-20	WY	Worland	CFH
WY95-1	WY	Lovell	Worland
WY95-2	WY	Lovell	CFH, Worland
WY95-3	WY	Lovell	Worland
WY95-5	WY	Worland	CFH, Worland

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# **SUGARBEET RESEARCH**

## **1996 Report**

### **Section I**

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# Investigation of *Trichoderma harzianum* Biological Control of *Rhizoctonia solani* Disease of Sugarbeets in Laboratory and Field Studies

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## ABSTRACT

Biological control of pre- and post-emergence damping off and root rot of sugarbeets caused by *Rhizoctonia solani* was demonstrated in the laboratory with two strains of *Trichoderma harzianum*, Tex and T95. The rhizosphere competent mutant of *T. harzianum*, T95, colonized sugarbeet roots at significantly higher levels than the wild type parent, Tex. Biocontrol could not be assessed in the field trials, as disease was not established in 1994 and excess disease developed in 1995. Additional keywords: rhizosphere colonization, suppressive soils.

## INTRODUCTION

*Rhizoctonia solani* causes severe disease on sugarbeets, including pre- and post-emergence damping off, root rot, crown rot, foliar blight, and dry canker on mature beets (5). *R. solani* is a soil-borne fungus distributed throughout the sugarbeet growing regions worldwide (11,19,21). *R. solani* overwinters as sclerotia and exists saprophytically in soil (5). Biological control may be an option to decrease the crop loss to *R. solani* when chemical control of the pathogen may not be economically or ecologically favorable.

*Trichoderma* spp. show promise as biocontrol agents. They are antagonistic soil fungi that produce antibiotic compounds and parasitize a variety of fungi (3). *Trichoderma harzianum* has demonstrated effective biocontrol of *R. solani* disease of sugarbeets in the laboratory and in the field (1, 8, 9, 15, 21).

An isolate of *T. harzianum*, referred to as Tex in this paper, from soil naturally suppressive to



*R. solani* in South America, had biocontrol activity against *R. solani* in the laboratory (9). A benomyl resistant mutant of this biocontrol agent, generated by N-methyl-N'-nitro-N-nitrosoguanidine exposure of conidia, was found to colonize the full length of the roots of several plants (2). The rhizosphere competent mutant, T95, exhibited improved biocontrol capacity compared to the wild type (3). Rhizosphere competence of the wild type *T. harzianum*, or the mutant T95, was not measured with sugarbeets.

Various methods have been employed for application of *T. harzianum* to native soils to achieve population levels necessary for biocontrol (7). Seed applications placed the biocontrol agent in the arena of infection and allowed for root protection by rhizosphere competent isolates (3, 12). Additional biocontrol inoculum on solid carriers has been mixed in soil to increase populations of *T. harzianum* to protective levels (16, 21).

The purpose of this study was to determine the root colonization potential of the wild type *T. harzianum*, and the rhizosphere competent mutant, T95, on sugarbeet roots and their ability to decrease disease caused by *R. solani* under laboratory and field conditions. Two methods of introducing the biocontrol agents were tested; seed application and a solid granular carrier.

## MATERIALS AND METHODS

**Organisms studied.** The two isolates of *Trichoderma harzianum*, Tex and T95, used in the biological control studies were provided by R. Baker, Colorado State University (Fort Collins, CO). The pathogen, *Rhizoctonia solani* RE1 (anastomosis group 2-2), originally isolated from sugarbeets, was obtained from E. Ruppel, USDA (Fort Collins, CO). Sugarbeet (*Beta vulgaris* L.) cultivar HM WSPM9, susceptible to *R. solani*, was used in laboratory and field tests.

**Fungal preparations.** The isolates of *T. harzianum*, Tex and T95, used in this study were examined for the ability to parasitize *R. solani* RE1 when coinoculated on potato dextrose agar (PDA). Mycoparasitism was determined macroscopically, by growth of *T. harzianum* over the *R. solani* mycelia, and microscopically, by hyphal invasion by *T. harzianum* into the *R. solani* hyphae and subsequent lysis (6). To prepare conidiospores for laboratory and field studies, *T. harzianum* isolates were grown on PDA at room temperature until sporulation. Conidiospores were washed from

the surface of the plates by agitation in sterile water and passed through a 5 ml syringe packed with autoclaved glass wool. Spores were counted on a hemocytometer.

To prepare the solid inoculum, granular corn cobs ground to a 5-cm mesh size (Mt. Pulaski Products, Inc, Mt. Pulaski, IL), were autoclaved for 1 h on 2 consecutive days. Conidial preparations of *T. harzianum* Tex or T95, were grown for 48 h in 100 ml of liquid fungal growth medium: 10 mM  $\text{KH}_2\text{PO}_4$ , 5 mM  $\text{K}_2\text{HPO}_4$ , 2 mM  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.2% casamino acids, 0.1% yeast extract, 1.5% glucose and 0.01% trace elements (4). The mycelia and media were mixed with 4 liters of autoclaved corn cobs, referred to as granules. Liquid fungal growth medium, 100 ml, was mixed with the granules weekly. The granules were incubated at room temperature for 60 days prior to packaging for the field trials.

*R. solani* RE1 inoculum for the field and laboratory tests was grown on sterile, moist barley for 3 weeks, air dried, and ground uniformly to 0.125-cm mesh size in a Wiley mill (20). The number of propagules/g in the ground inocula was determined by plating serially diluted suspensions on PDA or *Rhizoctonia*-selective medium (RSA) (14). The *R. solani* inocula used in all studies were tested for pathogenicity on sugarbeets in the laboratory.

**Seed treatment.** Sugarbeet seeds were heat-treated to eliminate seed-borne microorganisms by immersion in sterile water at 50°C for 30 min and rinsed with five volumes of sterile water (17). This procedure was performed twice. The seeds were air dried overnight in a laminar flow hood and stored dry at room temperature until use. No microorganisms were detected growing from heat-treated seeds germinated on PDA. To place the biocontrol agents onto sugarbeet seeds, *T. harzianum* conidiospores were imbibed into the cortex of heat-treated seeds by a vacuum technique (17). For field trials, treated seeds were air dried overnight in a laminar flow hood, then counted and packaged. Seeds were transported to the field site in a cooler with ice. For laboratory tests, the seeds were planted immediately after imbibition.

**Root colonization.** To determine the rhizosphere competence of *T. harzianum* Tex and T95, a modified procedure by Sivan and Harman (22) was used. Sugarbeet seeds, imbibed with  $10^5$  conidiospores/ml, were planted in 200 ml autoclaved soil:sand:water (1:1:0.25 v/v) mixture in

Magenta boxes. Magenta boxes consisted of two clear plastic units, each 9.5 cm deep and 6.5 cm wide, joined to form an enclosed chamber (Magenta Company, Chicago, IL). Five seeds were planted 2 cm deep in each Magenta box. Boxes were incubated for 30 days at 26°C with a 16-h light cycle at an intensity of 58.8 microEinsteins per square meter per second ( $\mu\text{E}/\text{m}^2/\text{sec}$ ).

Plants were gently removed from the soil, measured and cut into 1-cm segments measured from the soil interface, with a flame-sterilized razor blade. Six segments, located the same distance down the root, were pooled in 40 ml sterile water and shaken 150 rpm for 5 min on a rotary shaker to remove rhizosphere and rhizoplane soil. The root segments were transferred to 40 ml sterile 0.5% Triton X 100 detergent (Sigma Chemical Company, St. Louis, MO) and the flasks containing the soil and the root segments were shaken for 1 h at 150 rpm. Dilutions of the water and detergent wash material were plated on *Trichoderma* selective agar (TSA) (10). The *Trichoderma* colony forming units (CFU)/ml were counted at day 7. Root segments were stained for microscopic examination with trypan blue by the method of Kormanik et al. (13).

**Biocontrol laboratory studies.** Initial investigations of the biocontrol capacity of *T. harzianum* Tex and T95 followed the procedure in Lovic et al. (17). *Trichoderma* conidiospores ( $10^1$  to  $10^4$  spores/ml) and hyphal fragments from *R. solani* ( $10^4$  propagules/ml) were imbibed onto heat-treated sugarbeet seeds and planted in sterile vermiculite in Magenta boxes. The experiment was performed on 10 plants per treatment. Incubation conditions of the Magenta boxes were as outlined above. Emergence was determined by day 7 and seedling survival of damping off was assessed by day 21. Biocontrol capacity was measured as improved emergence and survival above untreated control levels.

To approximate field conditions for biocontrol, soil from the field sites was used in laboratory experiments. An autoclaved mixture of soil:sand:water (1:1:0.25 v/v) was added to sterile Magenta boxes, 200 ml/box. *R. solani*-ground barley inoculum ( $10^3$  propagules/box) was mixed 2.5 cm deep before planting seeds imbibed with *Trichoderma* conidiospores ( $10^4$  to  $10^6$  spores/ml). In the tests with granules, 5.0 ml of granules was mixed to a depth of 2.5 cm before addition of the pathogen or treated beet seeds. All treatments were repeated on a minimum of 10 seeds. The Magenta

boxes were incubated and disease was assessed as described above.

**Biocontrol field trials.** The field studies were conducted at the University of Idaho Agriculture Research and Extension Center at Parma, ID. Two field trials, 1 and 2, were planted in May and July 1994 at site B5. Field trial 3 was planted at site D6 in May 1995. Site B5 received 0.88 g/m of the ground barley inoculum of *R. solani* in August 1993. The inoculated plants were disked into the soil in early September 1993. Inoculum was applied for the 1994 and 1995 field tests at 0.33 g/m for trial 1, 0.38 g/m for trial 2 at site B5, and 0.72 g/m for trial 3 at site D6. The soil at site D6 was not amended with *R. solani* prior to May 1995. In all field trials, the *Rhizoctonia* inoculum was metered uniformly into the seed row with a Gandy granule applicator (Gandy Manufacturing Co., Owatonna, MN) mounted on a six-row commercial Milton planter (Starco Manufacturing Co., Casper, WY). The *R. solani* inoculum was applied in seed rows over the entire field in each trial prior to planting.

Field trials 1 and 2 were performed with sugarbeet seeds imbibed with *T. harzianum* Tex or T95 conidiospores ( $10^5$  spore/ml), or sterile water for control treatments. Field trial 3 seeds were imbibed with  $10^4$  to  $10^6$  spores/ml of *T. harzianum* Tex or T95. Granules thoroughly colonized by *T. harzianum* Tex or T95 were applied with the seed at 20 ml per test row. Sterile granules were added for the control treatments. All treatments were arranged in a randomized block design with six replications.

Seeds were planted 2.5 cm deep with a six-row research cone planter following previous planter marks to ensure seed placement with the inoculum. Fifty heat-treated seeds were planted in each 7.6-m row with two rows per treatment for trials 1 and 3. Twenty-five seeds in each 6-m row with a single row per treatment were used in trial 2. Test sugarbeets were planted in different regions of the B5 site in field trials 1 and 2. Portions of the test site not planted to test beets were planted with a commercial sugarbeet variety. The field trial sites were furrow irrigated to field capacity after planting the seed in a dry field. Irrigation water was added as weather dictated during the field season.

Emergence at 8 days was recorded. Surviving seedlings were counted at 42 days postplanting for field trial 1, 21 days for field trial 2, and 23 days for field trial 3. The level of disease was determined on hand-dug sugarbeets on the harvest date: 64 days postplanting for trials 1 and 3, and

30 days for trial 2. A seven-point scale devised by Ruppel was used for disease index (D.I.) rating (11).

Roots were sampled in field trial 3 at 23 days postplanting to determine *Trichoderma* populations in the rhizosphere. Four sugarbeet roots from each treatment from two blocks were removed with adhering soil, packaged in sealed plastic bags, and transported in a cooler with ice to the laboratory. Roots were placed in 10 ml of sterile water and shaken vigorously for 1 min to release rhizosphere soil. Serial dilutions of this wash were plated on TSA and TSA amended with 0.025g/l active ingredient benomyl (TSAB) (50% wettable powder, Lilly Company, Portland, OR). Colony forming units were enumerated on day 10 after plating.

## RESULTS

**Root colonization.** *T. harzianum* propagules colonized the entire 5 cm length of the sugarbeet roots grown in a sterile soil mixture as determined by the water wash and colonization was seen to 4 cm by subsequent wash with Triton X 100 (Figure 1). Root colonization of sugarbeets by *T. harzianum* T95, the rhizosphere competent mutant, was significantly higher than the parental strain, Tex, ( $p = 0.05$ ) at root lengths of 3, 4, and 5 cm below the soil surface as determined by the water treatment (Figure 1). The population of fungi recovered from the root segments decreased with the distance from the soil surface with both the water and the Triton X treatments for *T. harzianum* Tex and T95. In microscopic examinations of trypan blue-stained root segments, roots appeared similar for *Trichoderma* hyphal growth along the external epidermal cells with all segments (data not shown).

**Biocontrol in laboratory studies.** Biocontrol experiments in vermiculite, with *R. solani* hyphal fragments and  $10^1$  to  $10^4$  spores/ml *T. harzianum* Tex and T95 applied to seeds, significantly improved emergence and survival above control levels at several spore concentrations ( $p = 0.05$ ) (Figure 2). Only 7% of the untreated control plants that emerged survived damping off in this system (Figure 2). Treatments with  $10^4$ ,  $10^2$ , and  $10^1$  spores/ml *T. harzianum* T95 allowed higher emergence than Tex, and survival increased for T95 at  $10^2$  and  $10^1$  spore/ml above Tex values (Figure 2).

In the sterile soil system, with *R. solani* applied as ground barley inoculum to the soil and *T.*

*harzianum* applied on the seed and on granules, significantly higher emergence and survival above the control levels were seen at most spore concentrations (Figure 3). There was no consistent difference in biocontrol capacity between the two strains of *T. harzianum* (Figure 3). Seeds treated with *T. harzianum* T95  $10^4$  spores/ml did not have significantly higher emergence, and seeds treated with Tex  $10^5$  and T95  $10^4$  spores/ml had decreased survival as compared to the control levels (Figure 3). Decreased survival of sugarbeets at higher spore concentrations may indicate a phytotoxic effect of high populations of *T. harzianum* in a sterile system. Added granules of *T. harzianum* significantly improved biocontrol capacity compared to seed inoculation alone for Tex  $10^5$ , T95  $10^5$ , and  $10^4$  spores/ml seed treatments ( $p = 0.05$ ) (Figure 3).

**Biocontrol in field.** Biocontrol capacity could not be demonstrated in the field trials because no differences between the control treatments and the biocontrol agents were found (Table 1).

*Rhizoctonia* disease was not established in field trials 1 and 2, as evidenced by the high percent emergence and survival and the low disease index (Table 1). The soils at this test site were suppressive to *R. solani* disease, although a virulent pathogen and a susceptible host plant were present.

*Rhizoctonia* disease developed extensively in field trial 3, with significantly ( $p = 0.05$ ) lower emergence and survival, and significantly ( $p = 0.05$ ) higher disease index when compared to field trial 1 and 2 (Table 1).

*Trichoderma* spp. were recovered from the rhizosphere of roots sampled for field trial 3 (Table 2). *Trichoderma* spp. were found in association with roots from all treatments, including control seed and granular treatments with no introduced *T. harzianum* (Table 2). Benomyl resistant *Trichoderma* spp. were isolated from rhizosphere soil for all but two treatments, irrespective of application of the benomyl resistant *T. harzianum* T95 (Table 2).

## DISCUSSION

Rhizosphere soils associated with sugarbeet roots were colonized to the root tip, a 5-cm distance, by seed inoculated *Trichoderma harzianum* Tex and T95. Populations were significantly higher with the rhizosphere competent mutant, T95. In studies by Ahmad and Baker (2) with bean,

cucumber, maize, radish, and tomato, T95 was found in rhizosphere soil the full length of the roots at 8 cm and Tex was found to a depth of 3 cm. Colonization of the entire root surface with a biocontrol agent should afford better protection from invasion by fungal pathogens (3, 12). Protection of sugarbeet roots from *R. solani* disease by seed and/or granular treatment with *T. harzianum* was seen in laboratory studies in vermiculite and soil.

A potential phytotoxic effect may be responsible for the lower survival of the host plant at the higher application rates of *T. harzianum* in the sterile laboratory studies. Phytotoxicity has been documented for antibiotic-producing bacterial biocontrol agents (18). The production of antibiotics by *T. harzianum* may be important for effective biocontrol (7, 12). Phytotoxicity was not a problem in native field soils as the *T. harzianum* seed and granular treatments were not significantly lower in emergence or survival from the untreated controls, possibly due to lower survival of introduced *T. harzianum*.

Addition of biocontrol agents on a solid granular matrix improved biocontrol over the seed treatment for concentrations of *T. harzianum* in the laboratory. The enhancement of populations of biocontrol agents by additional solid matrix amendment in the rhizosphere may be important in native soils (12).

In this study, assessment of biocontrol efficacy of *T. harzianum* against *R. solani* in the field was not possible because suppressive soils prevented disease establishment in the first two field trials, and extensive disease occurred in the third trial. Chet and Baker (8) reported suppression of *R. solani* disease of sugarbeet by *T. harzianum* at  $10^5$  propagules/g of soil. Whereas *Trichoderma* spp. were recovered from the rhizosphere of field planted sugarbeets for field trial 3, protective levels were not established. Recovery of benomyl-resistant *Trichoderma* spp. from native soil where *T. harzianum* T95 was not introduced precludes the use of the benomyl resistance marker for identification of recovered *T. harzianum* T95.

Further laboratory and field tests must be conducted to determine the parameters important for effective, reliable biocontrol of *R. solani* disease on sugarbeets with *T. harzianum*. The potential for successful reduction in crop losses with biocontrol agents has been shown under laboratory

conditions. This potential must be expanded to a practical level for use in an agricultural setting. The model system used in this study allows for investigation of the importance of rhizosphere colonization on biocontrol of fungal diseases. Biocontrol agents should be examined under conditions approximating field circumstances to accurately assess interactions between plant, biocontrol agent, and pathogen. Various methods of application to enhance the populations of the protective agent in the soil should be explored.

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**Table 1** Biocontrol trials of *Trichoderma harzianum* against *Rhizoctonia solani* on sugarbeets in the field

Field Trial 1			
Treatment	%E <sup>a</sup>	%S <sup>b</sup>	D.I. <sup>cd</sup>
Control	63 ± 10a	101 ± 11a	0.7
Control + Granules	63 ± 9a	97 ± 21a	0.9
Tex 10 <sup>5</sup>	69 ± 13a	91 ± 18a	0.8
Tex 10 <sup>5</sup> + Granules	72 ± 5a	96 ± 8a	0.9
T95 10 <sup>5</sup>	66 ± 11a	91 ± 18a	0.9
T95 10 <sup>5</sup> + Granules	66 ± 9a	100 ± 9a	1.0
Field Trial 2			
Treatment	%E	%S	D.I.
Control	61 ± 22ab	111 ± 16a	0.7 ± 0.3a
Control + Granules	57 ± 14ab	117 ± 25a	0.6 ± 0.3a
Tex 10 <sup>5</sup>	61 ± 16a	85 ± 17a	0.5 ± 0.3a
Tex 10 <sup>5</sup> + Granules	63 ± 5ab	93 ± 25a	0.5 ± 0.2a
T95 10 <sup>5</sup>	63 ± 14a	80 ± 6c	0.5 ± 0.3a
T95 10 <sup>5</sup> + Granules	61 ± 12a	100 ± 11a	0.3 ± 0.1a
Field Trial 3			
Treatment	%E	%S	D.I.
Control	47 ± 11b	49 ± 23b	6.3 ± 0.5b
Control + Granules	45 ± 18b	47 ± 13b	6.0 ± 1.0b
Tex 10 <sup>6</sup>	53 ± 10	54 ± 32	6.0 ± 0.8
Tex 10 <sup>6</sup> + Granules	45 ± 11	47 ± 23	6.3 ± 0.9
T95 10 <sup>6</sup>	46 ± 9	38 ± 18	6.4 ± 0.7
T95 10 <sup>6</sup> + Granules	52 ± 11	49 ± 17	5.9 ± 0.8
Tex 10 <sup>5</sup>	41 ± 13b	41 ± 27b	6.1 ± 0.7b
Tex 10 <sup>5</sup> + Granules	45 ± 11c	47 ± 19b	5.9 ± 0.9b
T95 10 <sup>5</sup>	48 ± 6b	50 ± 14c	6.2 ± 0.4b
T95 10 <sup>5</sup> + Granules	47 ± 10b	37 ± 20d	6.3 ± 0.5b
Tex 10 <sup>4</sup>	46 ± 18	42 ± 11	6.1 ± 0.6
Tex 10 <sup>4</sup> + Granules	47 ± 17	50 ± 27	6.1 ± 0.8
T95 10 <sup>4</sup>	47 ± 13	45 ± 22	6.1 ± 0.9
T95 10 <sup>4</sup> + Granules	39 ± 7	32 ± 23	5.9 ± 0.7

(Table 1 continued)

<sup>a</sup> %E percent emergence = (#plants emerged /# seeds planted) x 100 ± standard deviation.

<sup>b</sup> %S percent survival = (#seedlings surviving /# plants emerged) x 100 ± standard deviation.

<sup>c</sup> D.I. disease index = level of disease symptoms at harvest ± standard deviation. 7.0 scale used for D.I. ; 0.0 = no symptoms, 7.0 = 100% rot.

<sup>d</sup> D.I. for field trial 1 was assessed on one block.

All other data were based on values for six replicate blocks for each field trial.

D.I. was significantly higher in field trial 3 than for field trial 1 and 2 for all treatments at  $p = 1 \times 10^{-5}$  by t test for paired means. See Table A1 for statistical analysis.

Means for the same treatments, compared between field trials, followed by the same letter are not significantly different at  $p = 0.05$  by t test for paired means.

**Table 2** Populations of *Trichoderma* spp. recovered from sugarbeet roots from field trial 3

Treatment	CFU/root <sup>a</sup>	
	TSA	TSAB
Control	$5.9 \times 10^2 \pm 3.0 \times 10^2$	$3.8 \times 10^1 \pm 1.8 \times 10^1$
Control + Granules	$5.3 \times 10^2 \pm 1.0 \times 10^2$	$1.1 \times 10^2 \pm 1.8 \times 10^1$
Tex 10 <sup>6</sup>	$3.3 \times 10^2 \pm 2.7 \times 10^2$	$6.3 \times 10^1 \pm 5.3 \times 10^1$
Tex 10 <sup>6</sup> + Granules	$3.4 \times 10^2 \pm 2.7 \times 10^2$	0
T95 10 <sup>6</sup>	$2.4 \times 10^3 \pm 1.8 \times 10^3$	$6.3 \times 10^1 \pm 5.3 \times 10^1$
T95 10 <sup>6</sup> + Granules	$8.5 \times 10^2 \pm 2.1 \times 10^2$	$7.5 \times 10^1 \pm 1.1 \times 10^2$
Tex 10 <sup>5</sup>	$7.9 \times 10^2 \pm 1.6 \times 10^2$	$2.6 \times 10^1 \pm 3.5 \times 10^1$
Tex 10 <sup>5</sup> + Granules	$1.3 \times 10^3 \pm 2.1 \times 10^2$	$3.0 \times 10^2 \pm 3.5 \times 10^2$
T95 10 <sup>5</sup>	$9.6 \times 10^2 \pm 1.2 \times 10^2$	$4.8 \times 10^2 \pm 4.2 \times 10^2$
T95 10 <sup>5</sup> + Granules	$5.9 \times 10^2 \pm 2.3 \times 10^2$	$1.3 \times 10^1 \pm 1.8 \times 10^1$
Tex 10 <sup>4</sup>	$5.3 \times 10^2 \pm 2.5 \times 10^2$	$3.8 \times 10^1 \pm 5.3 \times 10^1$
Tex 10 <sup>4</sup> + Granules	$5.0 \times 10^2 \pm 2.8 \times 10^2$	0
T95 10 <sup>4</sup>	$8.0 \times 10^2 \pm 2.1 \times 10^2$	$2.5 \times 10^1 \pm 0$
T95 10 <sup>4</sup> + Granules	$1.1 \times 10^3 \pm 1.1 \times 10^3$	$2.5 \times 10^1 \pm 0$

<sup>a</sup> CFU/root - colony forming unit/root enumerated on *Trichoderma* selective agar (TSA) or TSA + Benomyl (TSAB).

Data are from four roots from each of two test blocks. Roots were harvested after 23 days in the field, two plates of each type were counted.

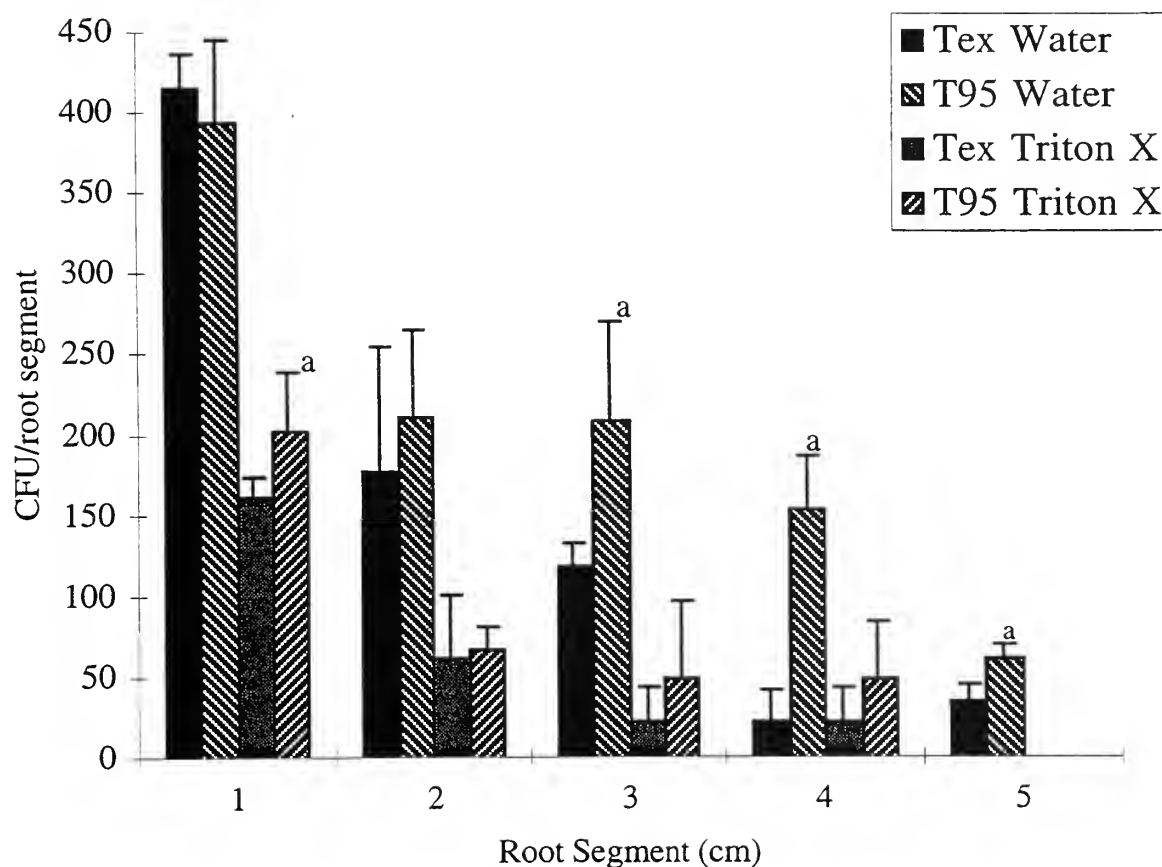


Figure 1 Root colonization of sugar beet by *Trichoderma harzianum* Tex and T95. CFU/root segment - colony forming units per root segment with 1 cm nearest the soil surface. Roots were washed with water, then Triton X 100, serially diluted and plated on selective medium. Data are the averages of four experiments with six roots analyzed in each experiment. \* indicate significant differences between Tex and T95 for the same treatment by t test ( $p = 0.05$ ).

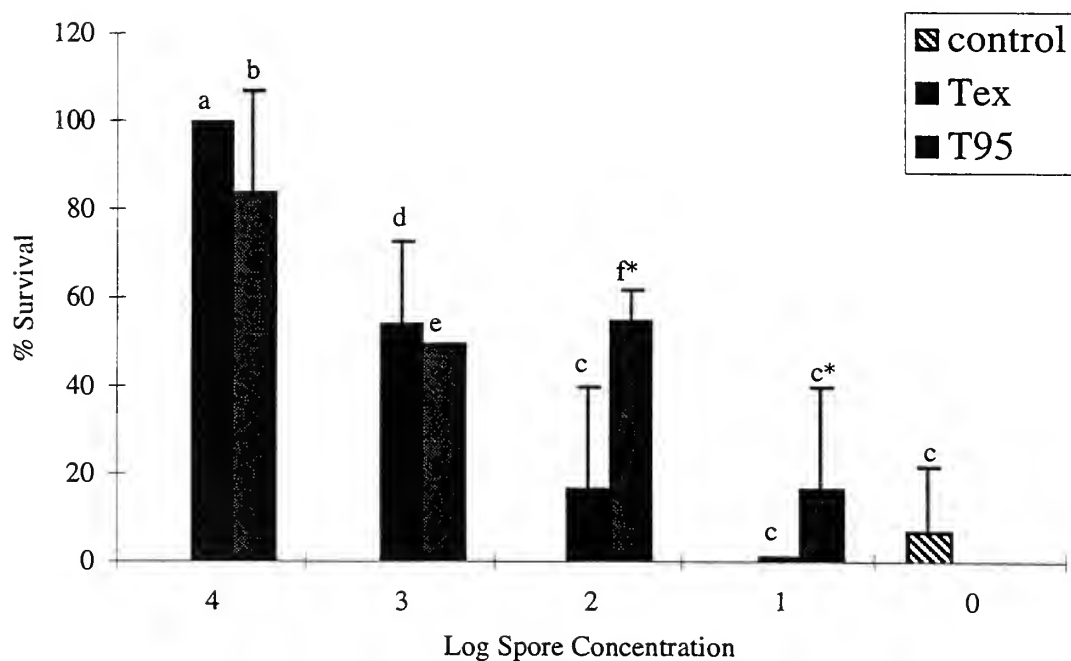
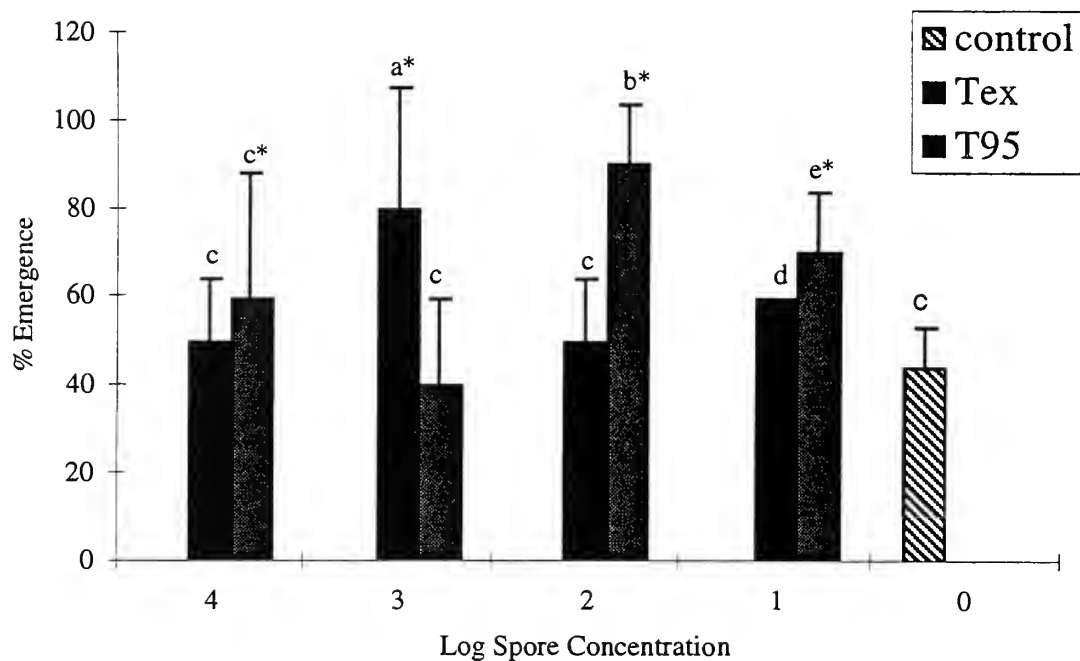


Figure 2 Biocontrol by *Trichoderma harzianum* Tex and T95 against *Rhizoctonia solani* disease in sugar beets in vermiculite under laboratory conditions. Data are from a minimum of ten plants. Different letters indicate significant differences compared to the control value by t test ( $p = 0.05$ ). \* indicates significant differences between Tex and T95 at the same spore concentration by t test ( $p = 0.05$ ).

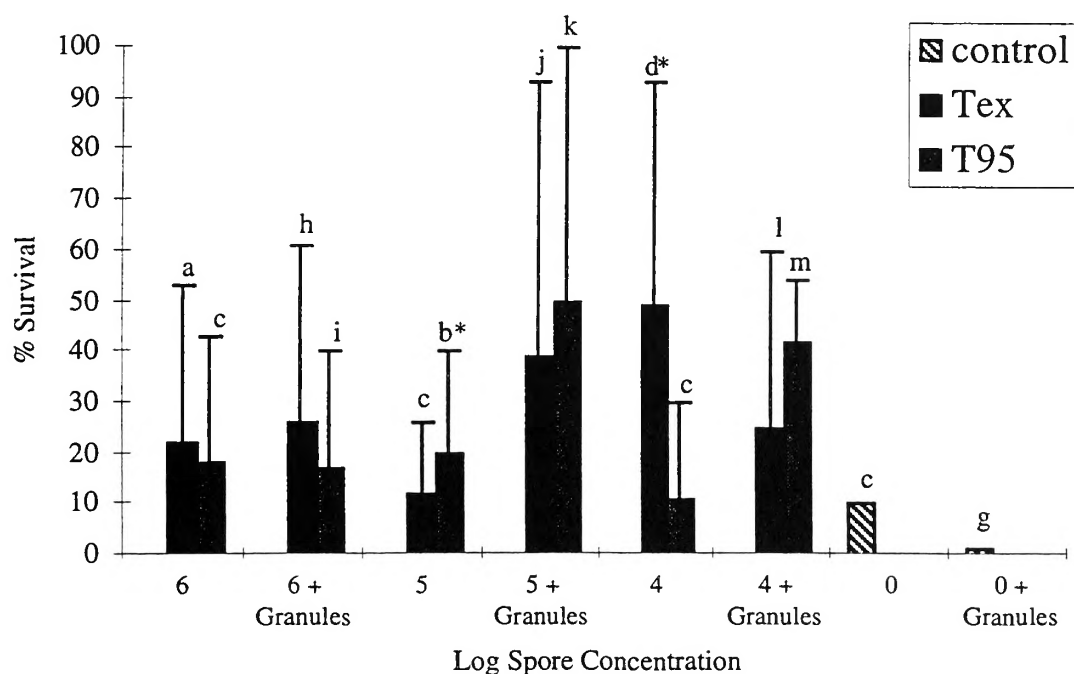
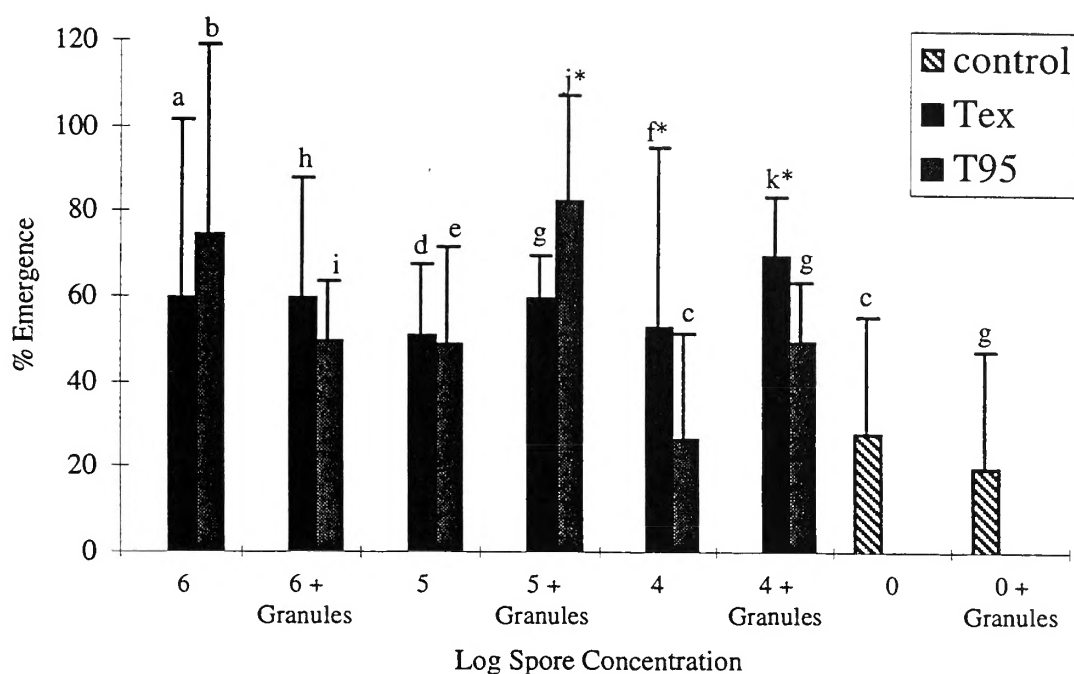


Figure 3 Biocontrol by *Trichoderma harzianum* Tex and T95 against *Rhizoctonia solani* disease in sugar beets in sterile soil under laboratory conditions. Data are from a minimum of ten plants, additional experiments were performed when test materials were available. Different letters indicate significant differences compared to the control value or the granular control value respectively by t test (p = 0.05). \* indicates significant differences between Tex and T95 at the same spore concentration and same treatment, no granules or with granules by t test (p = 0.05).

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